CHAPTER 1

DEFINITIVE CHALLENGES

We are a community of Humans occupying a complex niche on planet Earth. We have severely surpassed the carrying capacity of this niche, a situation that is now putting our global society at risk of global instability and collapse. Ecological sense would advise us to have and to implement an escape strategy that must include a reversal of our population growth and its consumption of the natural resources.

A. GLOBAL CHANGE

A.1 HUMAN PREDICAMENT

1.1a Resource Debt. The planet's human societies and its ecosystems are experiencing strong destabilizing trends to which national governments are not adequately responding. The root causes of these trends are global overpopulation and overconsumption. Overpopulation is increasing the demand for consumption; and overconsumption is reducing the supply of renewable natural resources to a point of critically destabilizing global human society. The industrial revolution of the eighteenth century resulted from colonial access to the resources of the New World that led to labor-saving machines that used cheap fossil energy. The resulting huge increases in productivity spurred the development of modern societies and a culture without resource limits. Today we are still simultaneously ignoring and paying the impossible cost of this fallacious approach. The Human Predicament derives from the inability of humans to manage a quick and effective response to the multiple impacts that are now destroying the human habitat.

A recent accounting, of the earth's biocapacity[1] (supply of goods and services from nature) and the human ecological footprint[1] (demand for this biocapacity) indicates that we are consuming much more than what nature can replenish every year and are continuing to devour the remainder. To put it another way, we are far past our carrying capacity[2] **(**and have been more and more so since the 1970s), and are currently consuming more than 150% of the renewable resources that earth's annual production can supply (Fig. 1). It is the divergence between these two trends of demand and supply that calls for an urgent transition to sustainability. The reasons for this overshoot are economic, governmental, and cultural. In short, our technical capacity combined with our for-profit economy have together outstripped our social responsibility and our ability to wisely manage our societies and our environment. This

puts the entire human society in a very precarious, unstable, and unsustainable condition. The transition to a more stable and sustainable world is still technically possible on the condition that we can obtain a critical level of public awareness, a restructuring of the global economy, a complete political commitment to Sustainable Development in accord with the United Nations, and a thorough collective international effort toward cooperative agreements.

The expression Global Change (GC) represents the degradation caused by the exceeding of sustainable limits of both the natural and human systems by all nations. In an effort to grow their financial wealth, the over consuming societies tend to shield themselves from these problems; and they continue to pursue increased material wealth, while ignoring their dependence on the rest of the world, and by neglecting their need for sustainable solutions. On the other hand, the overpopulated societies, severely affected by economic inequality, continue to gamble on large families, to consume resources for their survival, and consequently, become less and less able to initiate sustainable solutions. Thus, overpopulation and overconsumption are the root causes of all the GC impacts, which together with the ignorance and lack of will of to cooperate in solutions creates the Human Predicament.

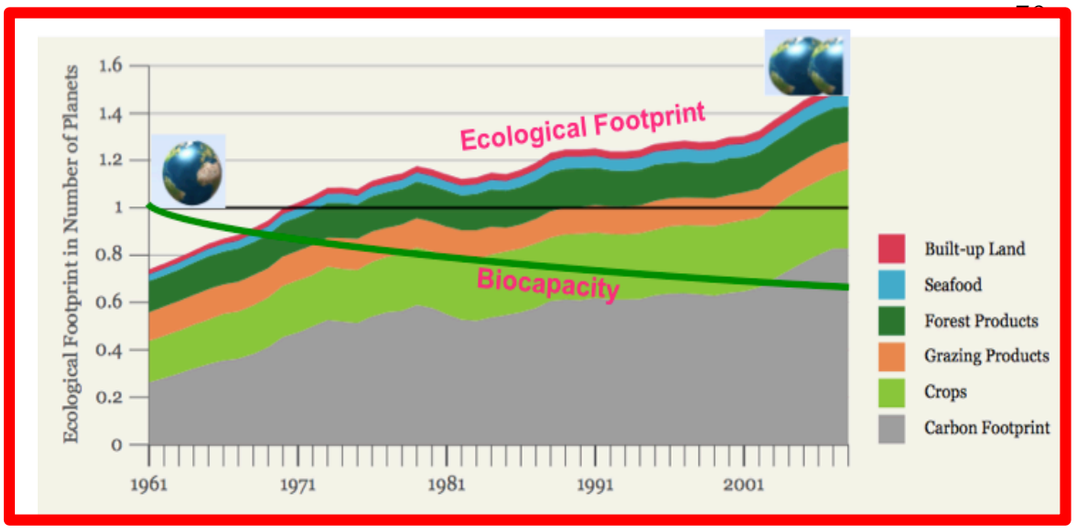

Fig. 1. Depiction of the Ecological Footprint (ascending red line) indicating the demand for renewable resources and of the Earth's biocapacity (descending green line) indicating the available supply of Earth's production of these resources. The graph is normalized to values estimated to exist in 1961— symbolized by the globe to the left - and extend to those in 2012—symbolized by the globe and a half to the right. In other words, by 2012, humanity was consuming 150% of the earth's production relative to 1961. The color code on the right legend indicates the contributions of the various human activities listed. The carbon footprint portion (gray, and 55% of total) is a measure of the human disruption of the Carbon Cycle that is changing the climate and impacting the ocean and land resources. Graph from Footprint network[3]. The biocapacity plot was calculated from data from the same source.

It is through a lack of systemic self-regulation that these root causes have grown and have generated a collection of global mega-problems that are reducing our resilience and precluding a return to stability (Fig.2). The cumulative result of this situation is an exponential deterioration and destabilization of the natural systems that is threatening the continued support for the wellbeing perpetuation of all human societies. While we try to mitigate prominent impacts separately, we overlook the preventive measures needed to reduce the two root causes, that is, by changing the controls that can regulate them (Fig.2). All of these impacts are so strongly interconnected that any combination of several of them could collapse modern society, whether through economic collapse, population die-off, or nuclear war[4] (Fig. 2).

Any of these collapse scenarios is clearly possible as an extension of the present global condition, and several of whose worst aspects are: financial instability, rampant malnutrition, infectious diseases, social unrest, failed states, border wars, mass migrations, and nuclear proliferation. The main point of Fig. 1 is that time is a severely limiting factor— an urgency compounded by the continuing rate of depletion of per-capita resource wealth, which makes our global society increasingly dysfunctional, and which depreciates our capacity to effect rational and just governance. Collapse could mean a gradual loss of functionality and resilience, or it could mean abrupt phase shifts or huge natural disasters capable of precipitating a cascade loss of functionality and of resilience in all sectors of human society. But slow or fast, collapse is inevitable unless we immediately change course and accelerate sustainable development. We note that the symbolic consensus of hope from the UN Summit[5] 2015].

Global collapse-avoidance requires an immediate change in how we manage the two root causes (Fig. 2) through a cooperative restructuring of management controls, especially the economy and government (cf. Chap. 3 and 4). The best approach to alleviating the degree of collapse is to initiate constructive corrections to these management controls and orient them towards resilience building for nature, and sustainable development for societies (cf. Chaps. 4 & 5). In addition, the approach and concurrently assist the human community to understand these two goals and the social, self-organizational[6] processes required for the transition to more sustainable societies. With these measures and other (Chap. 5), we certainly be able to soften the collapse and rebuild from it. Currently, the socially destabilizing consequences of GC (Fig. 2) are robbing us of the time and the money urgently needed to devote to their solutions to prevent anarchic degradation of our civilization.

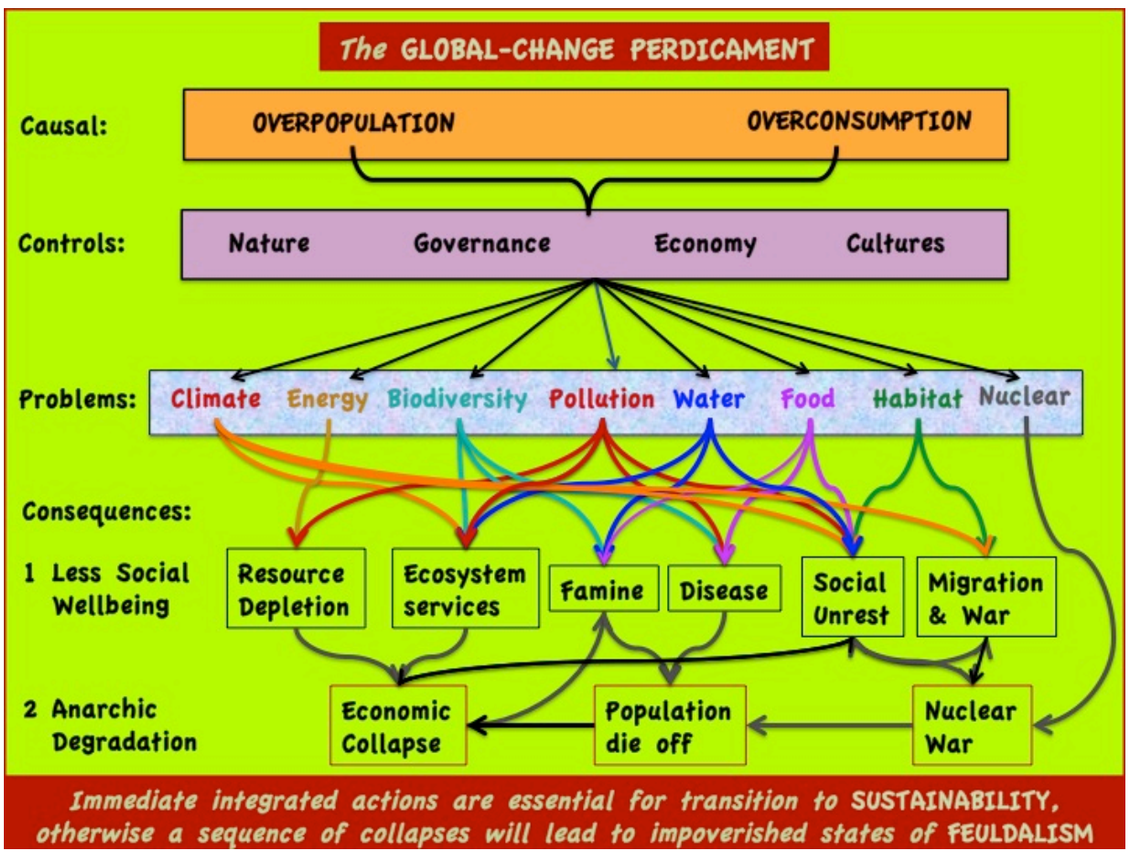

Figure 2. Schematic of the cause-and-effect links of Global Change caused by overpopulation and overconsumption. These two causes have not been seriously addressed by the governing elements. Without intelligent controlling these two root causes, permits a continued growth of the major problems that are now threatening the stability of human

habitat. These problems act both directly and indirectly, through a complex set of mutual interactions that are degrading the stability and the level of wellbeing of human societies. With continued degradation of resources, human society is becoming more susceptible to a cascade collapse in the form of economic disintegration, population die-off, and/or war. [Author generated[7]]

1.2a Wealth Gap. Today, humanity finds itself globally separated into three types of nations according to their access to resources and their accumulated wealth. These types are as follows:

1) The most developed countries (MDCs), which have achieved an industrial transition and are presently ignoring resource limitation.
2) The least developed countries (LDCs), which have not made the industrial transition and suffer from a lack of per-capita resources, due to a natural lack of them and/or to their exportation.
3) The developing countries (DCs), which form an intermediate group of nations between MDCs and LDCs that are mostly following the industrial trajectory of the MDCs and thereby are rapidly increasing their resource consumption.

The MDCs have maintained growth economies based on consumption of resident resources and those imported from other countries. The LDCs have been mostly left out of the benefits derived from the world's resource pool and are left to scavenge for survival because they lack the social and political infrastructure either to exploit their own resources or to prevent richer nations from exploiting them. Both DCs and LDCs aspire to MDC ranking. In this regard, it is of utmost importance that their development does not follow the polluting and unsustainable trajectory taken by the MDCs, but that they instead optimize the process of leapfrogging to renewable energy sources and its infrastructure. efficient technologies, non-polluting industries, and just wages and social services.

All three of these national categories point toward increased resource consumption. Our global economic model converts raw resources into financial wealth and environmental debt. The social consequence of competition for resources is causing an exponentially increasing wealth gap between the MDCs and LDCs that generates a growing social unrest among LDC populations striving for greater equality and freedom. The DCs and LDCs continue to overpopulate due to lack of birth control, male irresponsibility, lack of education and health care for women, and the need for more family labor for subsistence. International resource competition accentuates a global financial instability, manifested by an extraordinarily large and growing wealth gap (Fig. 3). Humanity is hog-tied into this egregious situation by the fact that none of the MDCs, DCs, or LDCs can solve their part of the problem independently of the others. This inability is made even worse because these destabilizing trends have inertia, and our ability to respond to them has an excessive lag time (circa 2-3 decades).

Our growing resource appetite is inhibiting a sustainable future

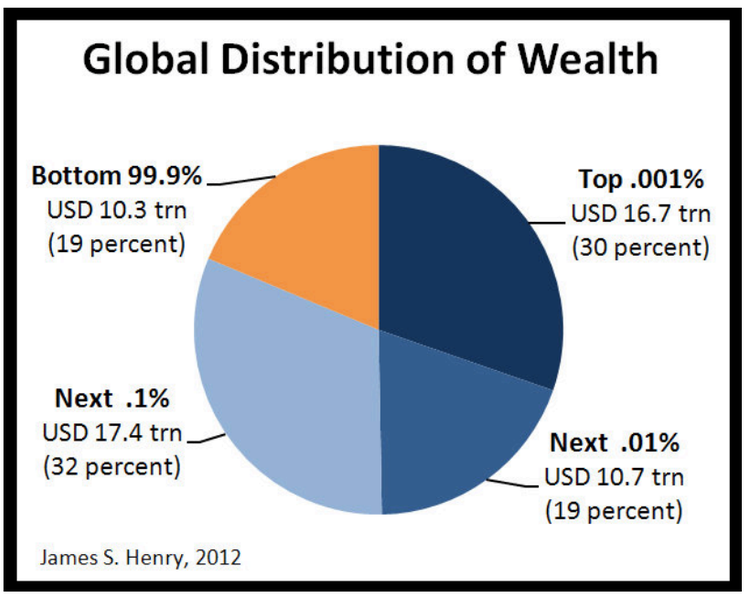

Fig. 3. Global Wealth Inequality. The distribution of total liquid net worth in the world per person in 2012 is divided counter clockwise: into the top 0.001% (91 thousand people), the next .01% (800 thousand people), the next 0.1% (8 million people), and the bottom (7 billion people Source[8].

The current US economy allows wealth to accumulate upward where it is retained by means of certain tax levels for individuals (like the hedge-fund manager exemption) and numerous loopholes for corporations (like those allowing them to offshore their profits to tax havens). Real wages are stagnant or falling for the majority of the population, and the tax burden has been shifted away from the wealthy and onto middle-income workers. The dynamic of: ”the rich get richer, and the poor get poorer” is valid at a national level and contributes strongly to social and political inequalities in the form of: high inequality stifles upward mobility, partitions the levels of education and reduces health care, marginalizes the lower income levels, and over-concentrates political power at the financial top, which allows them to control legislations favorable to them. (cf. Ch. 4.3).

Global wealth distribution (Fig. 4) is also strongly differentiated geographically. From a political perspective, this mal-distribution will inhibit fairness in pursuit of the collective agreements on trade, resources, and the technological practices needed for sustainable development. From a sustainable-development perspective, a more improved wealth distribution would favor more efficient formation of just, sustainable resource agreements between local and contiguous nations (cf. Ch. 5).

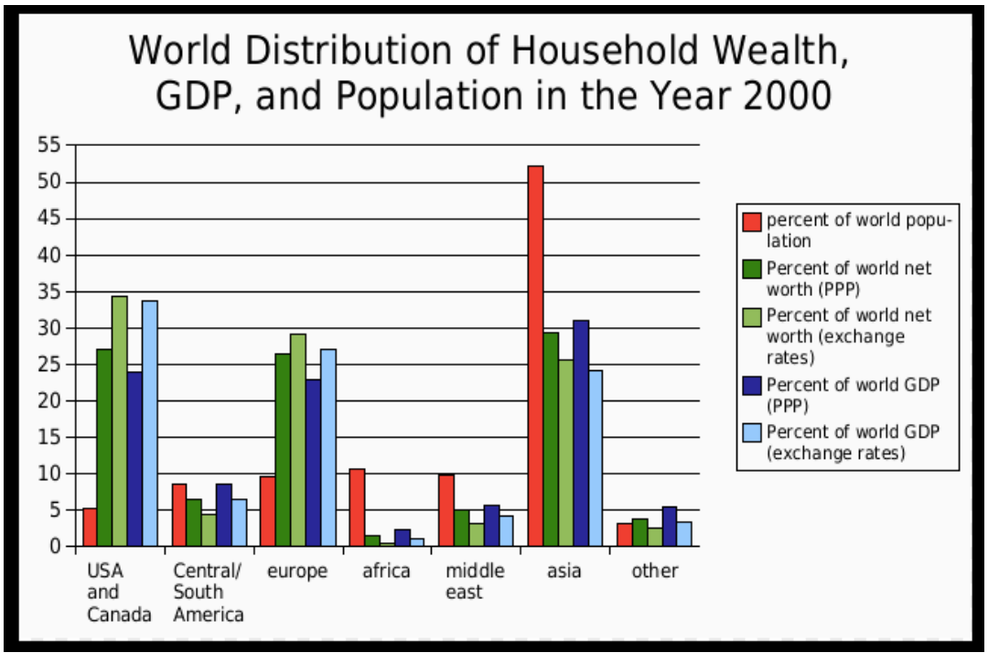

Fig. 4 Global Wealth Distributions by Regions 2000. The regional differences in population (red) and wealth (green) and in GDP (blue). The population is geographically concentrated in Asia and the wealth in North America and Europe. Source[9].

1.3a Paradigm Shift. If Global Change creates the Human Predicament, why can’t we address our options: do we continue to destroy the natural systems that provide our goods and services, or do we cooperate to preserve our planetary habitat and its productivity? The answer appears to be a combination of the following causes:

1) Because political leaders and commercial information media do not adequately present the facts (or actively suppress them), a plurality of the population doesn’t understand the crisis, or that it is already happening.
2) These same sources promulgate the soothing belief that we can adapt, or find the technological fix, for any and all consequences that might occur; and

3) Those that recognize the crisis but feel powerless are consequently inclined to believe that either the crisis will somehow resolve itself or it will be resolved by the oppressive measures.

These hesitations are not because we fear we cannot find a way deal with GC, but more likely that the rich third do not want to share their material and financial wealth with the poorer two thirds. This lifeboat ethic is based on a false premise that the rich are superior and will somehow survive, when the reality is quite the opposite because the rich live at the top of a house of economic and social cards, have more to lose, and cannot subsist by themselves without their social, environmental, political support. In contrast, the world's poor and working classes have relatively little to lose and loss is not unfamiliar to them. They are more habituated to living with resource scarcity and have experienced survival living through sharing collectively in their common interest.

The Human Predicament urgently calls for an extra-large paradigm shift in how we manage our modern societies (Fig. 4). The reversal of the negative Global Change issues cannot be simply 'fixed'; they will require a transformation of our economy and an improvement of our democratic governance to support the goal of long-term sustainability. Required, for example, is a holistic systems approach (cf. Chap. 5.4) that ensures a precautionary global integration of how we evaluate, anticipate, and resolve the impacts of Global Change. The implementation will require an incrementally balanced sequence of decisions that ensures resilience-building before each proposed change in order to avoid precipitating a set of internal collapses.

The most difficult resilience-building tasks are the initial ones of achieving public understanding of the necessity of sustainability and the political will to drive appropriate management of their societies. Current convention might prioritize the sequence of actions as follows: the need for public awareness precedes the public will for urgent action, which precedes the political will, which precedes the agreement for global cooperative action, which precedes finally a social-technical methodology for its implementation. However, these components of implementing sustainable development need not be sequenced in time; a preset manner; instead efforts to implement them will occur in a more-or-less contemporaneous and overlapping manner. They will remain, according to their compatibility with connected components. Therefore, the sequence for implementation should not rigidly ordered from the top, but the top should support the re-integration of ill-fitting components. This is because sustainability is necessarily a type of bottom-up governance and its development begins with a critical level of public awareness that includes the many already existing efforts towards sustainability. When this knowledge permeates all the action components of the conventional sequence, it will trigger a self-organizational process that generates innovations within and across the components. Finally, the integration of all components can be balanced (computer models) to optimize goals, such as energy-use, biocapacity, wellbeing, and social justice. As societal acceptance and practical engagement with the shared goal become more popular, the process of sustainable development will strengthen and become spontaneous and self-regulating, (cf. Ch.. 5.).

Failure to respond discredits our social intelligence.

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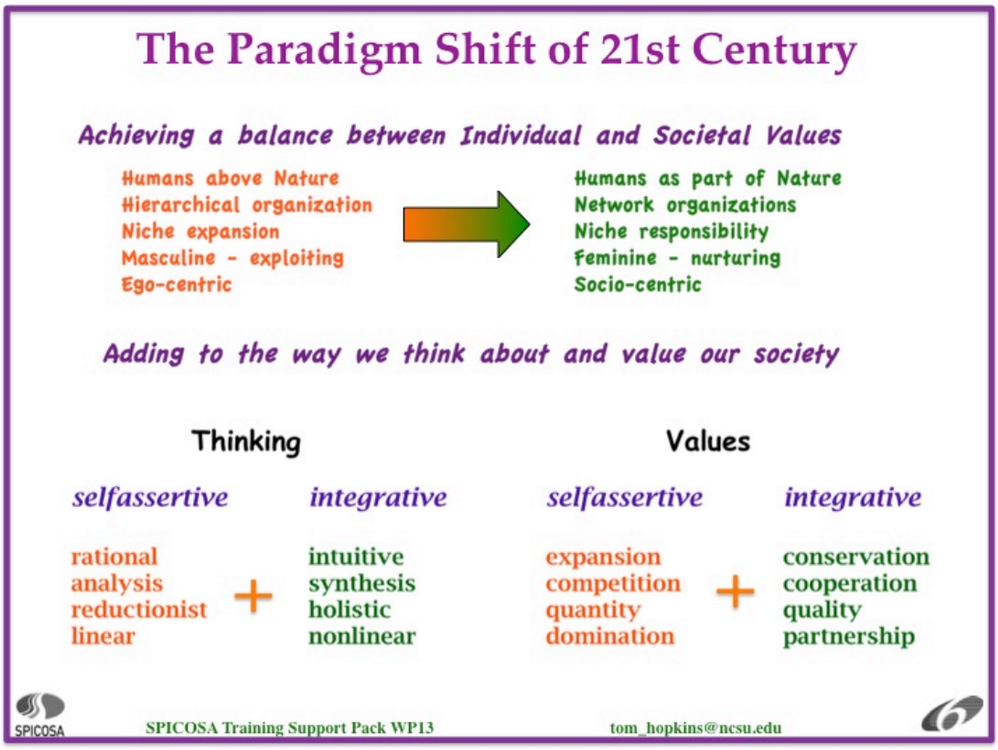
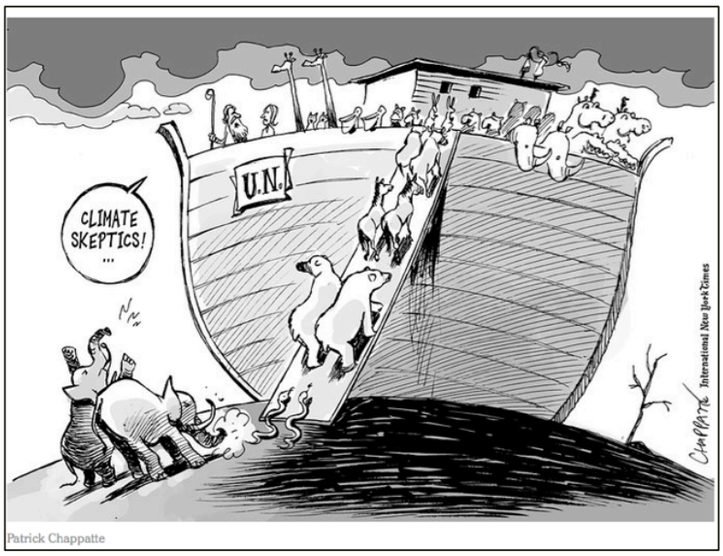


Fig. 5 Diagram of the Paradigm Shift of the 21st Century. To achieve the outcomes shown requires changes in the way we think and interact with others and with nature. The goal is a balance between societal and individual needs, and in order to better balance the distribution of well-being among the entire human community. [Author generated[10]].

1.4a Global Self-Organization. A global societal transformation (self-organization) is both essential and inevitable – It is what have to work with that determines the quality of the results. Positive environmental and social self-organizations are already occurring, but they are difficult to recognize amidst the intensity of the existent destructive practices like fossil-fuel production, top-down hierarchical structures, low minimum wages, ignorance of human rights, etc. Responding to this exigency, currently, is a highly diverse and rapidly growing body of the electorate that consists of individuals and organizations dedicated to enacting the cooperation and remediation needed to achieve a sustainable equilibrium among human societies and with the natural systems that support them. These voices need to dominate the dialogue towards an integrated, transdisciplinary plan on how we can orchestrate a balance between human material needs and resource-use that would provide a decent, sustainable universal living standard. However, without recognition and guidance, the goal of betterment for humanity will not necessarily emerge unless supported by a cooperative leadership of world authorities.

Thus, the expression 'Human Predicament' represents the uncertainty concerning whether human societies will succeed in their struggle to counter their excess consumption, population growth, and social inequalities, or else undergo feudal (or LDC-level) mal-distributions of wealth and to self-destruction. The key to winning this struggle is in the reversing of de-facto paradigms, such as that "*quantity is better than quality",* that *"competition rules over cooperation*", and that "*only the rich will survive*." (Figs. 5a, b). Yes, this essential paradigm shift of short-term effort for long-term gain will be initially difficult, but it will eventually become self-perpetuating. Currently, too many of us remain ignorant of the benefits and too many of our leaders are not even aware of the sustainability crisis, which still remains on the sidelines of the US political agenda.

On the dark side, the driven by increasingly massive protests, the current US administration was enacting moves toward this recognition (climate change mitigation, minimum wage, cooperative international accords). Moves toward greater sustainability are a UN priority[11] and are blossoming within communities and will continue to do so as the need for and benefits of sustainable development become more obvious and more feasible.



B. Climate Change

B.1. Defining the Issue

1.1a Earth Systems. In this document, we will make frequent reference to systems and their characteristics. A system is an integrated set of processes that has a definable function. The adjective 'complex' emphasizes that a system can change its function, composition, and structure through a self-organizational process stimulated by its internal interactions between its subsystems, or by interactions with externally connected systems. For this discussion, we will represent the Earth System as composed of four major subsystems: the natural systems (Terrestrial, Marine, Atmospheric, plus the emergent Human system, often referred to as 'Anthropic' (Fig. 6). Each of these subsystems is composed of networks of smaller component systems.

2.1b Systems Perspective. A characteristic of complex systems is that their equilibrium is sensitive to both external and internal disturbances. When two systems are dynamically coupled, a disturbance in one system can create disturbances in the other system. Each system has levels of resilience that allow them to recover their equilibrium, or not, from internal or external disturbances. Systems, including the internal systems of organisms, recover through feedback loops, e.g. as our immune system does from a cold after exposure to germs. However, if local external disturbances exceed the resilience capacity of a living species for a long enough time, and if it can't migrate to a better environment, it will perish. Our current excessive rates of species extinction are due to human disturbances weakening the resilience of plants and animals through habitat destruction, changing climate, increasing pollution, and overharvesting. Efforts to conserve biodiversity[12] equate to efforts to conserve resilience, which translates to an essential factor in our transition sustainable management of ecosystems.

With regard to Climate Change, the human system is disturbing the atmosphere with GHG emissions, chiefly carbon dioxide, methane, and nitrous oxide. As the upward trend in emissions continues, the inter-system disturbances will continue to increase in intensity and complexity in a manner mostly unfavorable to the three Natural systems. Since the initial human disturbance is a continuing trend and not just an event (as a large volcanic eruption), the atmosphere must continue to internally adjust, and likewise so must the marine and terrestrial systems. That is, as these systems surpass their resilience thresholds, they adjust through a self-organizational feedback process to a more highly entropic state (that is, degrade to a less complex and less ordered state). Important examples of such changes in Earth Systems due to climate change are:

- The northern **atmosphere** changes its polar circulation—because its boundary (the Polar Sea) changes from ice to water, which exposes the surface water to evaporation. This warms and humidifies the air, making it less dense, causing it to rise and thereby disturb the vertical structure of the polar vortex, which in turn slows and expands the jet stream's north-south oscillations. This both unusually warm and cold weather patterns in the sub-polar and mid-latitudes.
- The **marine** trophic changes—because as atmospheric CO_2 increases, more of it is dissolved in the ocean. This makes the water more acidic, which then renders the ocean less able to support organisms that use calcium carbonate, such as corals, shellfish, and some phytoplankton species.
- **Terrestrial** ecosystems and agriculture change—because they cannot adapt to the rates of warming temperatures and changing rainfall patterns.

These climate-change impacts are acting to weaken important aspects of the Human system's resilience, because the supporting Earth systems are losing their resilience and becoming less stable relative to their original equilibria. In other words, as the three Earth systems continue to lose their resilience, we are losing plant and animal species, and their functionality; we lose the biocapacity that we depend on.

Ironically, the most important loss of our resilience comes from our inability to respond to the CC disturbance and to confront its root and intermediary causes of overconsumption, neglect of resource value, emissions, bad land-use,. A non-response on the part of the human system would constitute a 'positive feedback' (enhancing the disturbance), whereas human actions that counter the disturbance would constitute a 'negative' feedback (quelling the disturbance). For example, if we don't like the way the climate is responding to our disturbance (GHG emissions), we could respond with a negative feedback (cut off the emissions) such that the atmosphere would gradually tend to return to its normal equilibrium (with normal interactions).

We cannot guarantee the recovery of the historic equilibria of the Earth, Atmospheric, Marine, and Terrestrial Systems.

Unfortunately, this may not be the case if the atmospheric dynamics have already changed to accommodate the increased levels of GHGs. In other words, if we could immediately turn off the causal CO_2 emissions, the average amount of CO_2 accumulated in the atmosphere would decrease slowly because CO_2 has average residence time of 30-95[13] yrs. However, the CC disturbances would continue while the excess accumulation exists because the severity of CC impacts also depends on the duration of that persistence. In addition, many of the CC impacts are strongly linked to CC; for example, reduced ice cover lowers the amount of heat reflected back to space. Consequently, when the CO_2 accumulation starts to lessen, it will recede more slowly than it would have if the CO_2 absorption capacity of the earth's surface had remained at its starting point (cf. Chap 6). In sum, the CC impacts won't

shut off immediately, will weaken slowly, and will differ in effect, in accordance with a new equilibrium between the four earth systems.

Thus, a focus on cutting emissions is only part of the solution to returning to acceptable levels of GHGs. An even greater challenge is that of restoring the absorption capacity of the marine and terrestrial systems. By itself, the recovery of the atmospheric system would not ensure elimination the CC impacts, especially those for which the dynamics controlling the interactions between the atmosphere and the marine and terrestrial systems have changed irreversibly on a longer-than human time scale, e.g. the glaciers may not return, the sea level won't go down, forest ecosystems may not recover. Furthermore, the complexity of the recovery processes suggests additional uncertainties that many of the CC impacts may not return to their previous levels of intensity.

These complex uncertainties bear directly on how quickly we respond to climate change, which in itself creates more uncertainty. There is still a risk that too many societies are hesitating to commit to sustainable development. That is, the uncertainties and the lack of understanding of the urgent need generates a fearful perception that the situation is impossible and that changing to sustainable solutions is more frightening than the consequences of not committing to them. This brings us back to the need for public awareness of these GC impacts and the knowledge that they are threatening the entire planetary habitat and consequently impacting all humans, even those who are not responsible for causing them.

Concurrently important is the conviction that we must not be passive and that we must remember that the Human system has an advantage over the other Earth systems: consciousness and the ability to consciously self-organize as well as to transform the material basis of our societies by changing both core technologies (energy generation, agriculture, transportation) and core social relationships. Only we can save ourselves, in other words, with our superior intelligence and a consciousness that allows us to act deliberately to save our habitat and not have to wait for some genetic adaptation to a changed planet.

2.1c. The Role of Climate Change in the Global Change. Climate Change is caused directly by overconsumption and indirectly by overpopulation in the form of an excess of GHGs emitted into the atmosphere that the altered marine and terrestrial systems are less able to absorb. On both temporal and spatial scales, CC is the largest contributor to our excessive ecological footprint (Fig. 1). Its widely diverse impacts aggravate other major man-made problems (Fig. 2). This complexity is a result of the intimate connections between the Human System and the three natural systems illustrated in Fig. 6. The continuing increase in GHG emissions forces an extreme urgency for humans to respond. Of great importance for us to remember also is that the GHGs and other air pollutants (cf. EPA listing[14]are intermediary causes responsible for both GC and CC. As shown in Fig. 2, the primary controls that are mismanaging our society are those of our economy, governance, and culture. Any CC strategy that fails to recognize this will fail – as explained in later Chapters.

Fig. 6 A pictorial representation of the major components of the Earth's complex system with the Marine, Terrestrial, Atmospheric, and Human subsystems and their two-way connections. The three natural subsystems have evolved to interact with each of the others in such a way as to maintain a balanced equilibrium governed by the energy input of the sun. This equilibrium has evolved over a long history of change to its present form, which has maintained a balance despite significant variations in each of the subsystems and in the sun's radiation. The human system has emerged from an insignificant portion of earth's biological system to a uniquely significant subsystem that has greatly increased its interactions with each of the three natural systems (colored arrows). As a result, these natural systems are losing their resilience, and the human system is losing the quality and quantity of the goods and services that humans demand from these natural systems. [Author generated].

Climate Change plays two critical roles in our global transition to a sustainable, safe condition. On the negative side, CC acts to amplify the other Global Change problems. On the positive side, the approach needed to resolve CC should serve as a prototype strategy for resolving the other global problems. In other words, the approach and strategies needed to reverse CC overlap with those needed to resolve the other Global Change problems, many of which are both contributing to and aggravated by CC.

The fact that climate changes can have a very long reversal time, unlike the day-to-day weather events that we experience. The CC changes are events that evoke dynamic changes in its long-term equilibrium balance that reduce the resilience of the atmospheric, to recover from a strong volcanic event. Here, one must distinguish between the damage caused by and single event and that caused by an increasing trend in an event that grows in strength until its damage becomes more and more irreversible, and extends also the reversal time of those GC impacts that are dynamically connected with CC. Some examples of GC impacts for which the non-resolution of CC is extending reversal times are: the salinization of ground water in coastal aquifers, the desertification of grazing lands, the acidification of the ocean, and associated marine life. Without an immediate effective action plan, preventive reversal of some other GC impacts will likely extend far beyond the human time scale to that of hundreds or thousands of years, e.g. sea level, ice cover, biodiversity, and even the persistence of the human species. Note that all bets are off at the millennial scale when

the planet is scheduled to return to an ice-age due to less sunlight in the northern hemisphere as the earth ends its "interglacial optimum period."[15]

The complexity of these connections between CG impacts (Fig. 2) implies that the scientific work, international political cooperation, and national policies needed to solve CC will bear significantly on the resolution of the other global trends. It also implies that we must use a systems approach[16] that employs model simulations in a transdisciplinary framework composed of natural and social sciences working in tandem with the public and policy stakeholders (cf. Chap 5). Unfortunately, many in the US feel that we would be giving up our sovereignty by working in cooperation with the UN on CC. In reality, we would gain an essential collaborator and connections with the community of nations. A most important example where this framework is needed is in devising our best response to CC, which should begin by phasing out fossil fuel combustion and phasing in a transition to renewable energy from other sources. In Europe and in the US, this transition is already well underway, in large part due to the tireless efforts of a growing number of climate activists. For example, the Sierra Club[17] has been able to block the construction of over 400 new coal-fired power plants since the turn of the century. But the transition is still largely unsupported by government action and it is not proceeding fast enough to counter the rapid growth in GHG emissions from large MDCs like China, India, and Brazil as they urbanize.

2.2 Finding our Response

2.2a. Current Situation. For the last several decades, it has been difficult for the public to accept is that CC is already happening and that it will continue to increase in intensity and uncertainty. This difficulty holds equally for the policymakers who have wanted up-front predictions of risks and damage costs before committing to action. Initially, it was difficult for scientists to make defensible predictions due to a lack of data to valid their models. However, in the 1980s, trends in environmental parameters were becoming significantly different than their long-term averages, e.g. in CO_2 concentrations, sea level, air temperature, glacial melt, etc. These data allowed scientists to more accurately model extrapolations from which they could provide reasonable predictions with fewer uncertainties.

Our enemy is not CO_2, but our management system that can't find the off

In 1992 the Intergovernmental Panel on Climate Change[18] (IPCC) issued its First Assessment Report confirming that the atmospheric greenhouse effect was increasing due to excess emissions of GHG. In that same year, the UN Earth Summit issued its guide of 27 Principles relevant to Sustainable Development[19], one of which was that States should abide by the Precautionary Principle: i.e. "*Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*." Twenty-three years and much more accurate predictions later, the need for precautionary action is all the more urgent and justified. In 1992, George H. Bush signed the final text making the US a signatory to Agenda 21[20]. Since Agenda 21 was a legally non-binding statement, Congress was not required to debate it as if it were a treaty. It has remained much too controversial to pass approval in Congress, with the opposition arguing that it is "erosive to our sovereignty"[21] In contrast, 528 US cities have become members of ICLEI (Local Governments for Sustainability[22] that helps to implement the Agenda 21 and its concepts.

Two decades later, the internal adjustments of the atmosphere have become obvious, notably through changes in its circulations that now distribute greater excess heat and water vapor poleward in the form of more intense storms dispersed over larger geographic areas. These same atmospheric changes are driving changes in the Marine, Terrestrial, and Human systems. The ocean's equilibrium state is experiencing abnormal changes in its heat storage, its carbon balance, and its surface ice coverage, each of which drives further changes in ocean circulation, sea level, acidity, biological populations, and exchanges with the atmosphere. Likewise, the terrestrial system is also put in disequilibrium by these atmospheric changes, manifested by floods, droughts, loss of biodiversity, glacial melting, earthquakes, and unseasonal weather that in turn disturbs microbial, insect, plant, animal, and human populations. All of these changes bear on the biocapacity that humans depend on. If human activities were properly coupled to the three Earth systems, humans could self-regulate these activities in response to these impact signals and thereby sustain their equilibria. Instead the majority of the human population is still uninformed, in denial, or in opposition, and is not demanding a proactive and effective response, and hence allowing the impacts to increase. The US Republican Party platform, for example, criticizes the President for having raised the security risk status of CC to the highest level, that is, equivalent to the threat of foreign military aggression (an assessment backed by the defense Department!)[23].

2.2b. Confronting Climate Change. The options for humans in response to these signals are panicking, adapting, mitigating, or preventing (Fig. 7). Prevention means eliminating the causal conditions in order to allow the three earth systems to establish new interdependent equilibria. There is no guarantee that any of the systems would exactly replicate its historic equilibrium, because the changes that have occurred are not always or exactly reversible and because the initial conditions for the reversal in each case would be different. For example, a previously dominant species that has been weakened may not regain its dominance, the previous ice cover of the Arctic Ocean and polar atmospheric circulation may not recover, or the desertification of grasslands and forests of the continents, may not become re-established.

Examples of immediate mitigative CC actions that would significantly help stabilize climate are a roughly 80% reduction of total GHG emission sources and similar improvements in the land process for CO_2 absorption sinks. If both of these actions were quickly and resolutely taken, the eventual new equilibria of the three natural systems might be closer to the historic ones. Meanwhile adaptive strategies would be needed to conserve and assist vulnerable areas and populations. Concurrently and most importantly would be a first-order focus on preventive solutions to CC. Obviously, these actions will require large and difficult changes, but they will result in reducing our present ecological footprint and in restoring the biocapacity supporting it. However, achieving these goals will concurrently require changing to a sustainable economy, more representative governments, and global collective cooperation agreements (cf. Ch. 4 & 5).

2.2b Deciding when and how to act. Because of the complexity of CC, let alone that of CG, it is of paramount importance that we confront the CG issues in a holistic and systematic manner to minimize mistaken or poor policies. This raises a catch-22 dilemma that the needed new policies must be carried out by and through the projected new sustainable economy and modified sustainable government. An integrated systems approach framework[24] can best cope with such a dilemma (cf. Chap. 5 & 6). To minimize ineffective policy decisions, policy options are first simulated

and sorted into a synergistic sequence. This sorting matrix will involve parameters of urgency, importance, difficulty, risk, and valuations of costs and benefits based on inclusion of all three capitals. Basically, it will involve immediate adaptive policies that are straightforward and can act as constructive precursors for the more complex policies that have large risk factors, such as protecting populated coasts. The shift to focus on more complex or difficult policies must also begin immediately (model development) so that they can provide a graduated set of scenarios for policy options for mitigation policies that can support the essential preventive strategies that must eventually be enacted. The NOAA Earth Systems Model[25] is a valuable example of iterative simulations of scenario results.

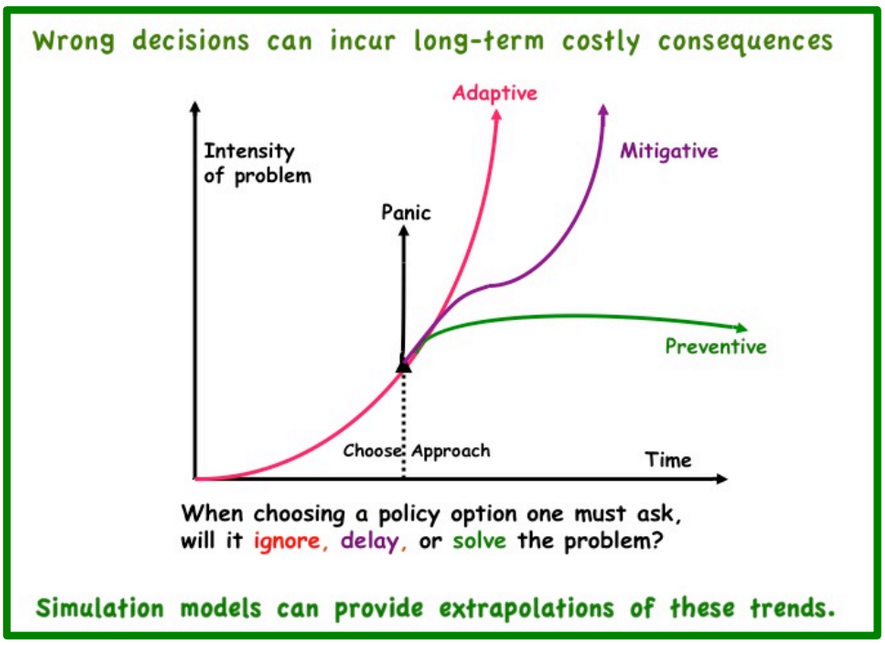


Fig. 7 There are four ways that we can respond to impacts: Panic (wrong response), Adaptive (live with it), Mitigative (lessen its effect), and Preventive (eliminate its cause). Rarely are problems static in dynamic systems: some change is inevitable. If the impact is increasing, it is important to select as high a level of response as feasible; and if not, to select one that can be upgraded, e.g., from mitigative to preventive. Methodology exists for simulating their trajectories relative to different management options, so as to guide management[26].

A sustainable energy plan must be inclusive of CC. In other words, the actions we take to resolve the CC issue must be building blocks of a sustainable energy plan, and vice versa. This plan would proceed with priority adaptive strategies that can be carried out with current management, meanwhile initiating feasible mitigative strategies that are at least feasible with an improving management and compatible with preventive strategies that require a transformed management. All practices must be designed to facilitate upgrades, and the total process evolves. Some (non-prioritized) examples of this sequence relative to the CC issue of strategies would be:

- **Panic** (maintaining unsustainable policies): Subsidizing oil and coal energy production; promoting industrial agricultural practices; not honestly explaining to the crisis to the public; continuing excessive consumption, not making the CC issue a national security priority.
- **Adaptive** (resilience-building policies): Imposing a gradually increasing carbon fee on FF sources[28]**;** divesting from FF equity assets; cutting carbon combustion; conserving energy by all means available; explaining to the public the need for and benefits of sustainable development; promoting the transitions of agriculture, industry, transportation, and power-generation to greater robustness and sustainability; protecting the coasts against sea-level rise,.
- **Mitigative** (infrastructure policies): Transforming the energy infrastructure for renewable energy; phasing out coal and unconventional petroleum (shale, tar, and gas fracking, and

agriculture biofuel); redesigning buildings for energy conservation; modernizing local and national rail; encouraging installation of photovoltaics on buildings; re-designing the electrical grid for local generation; using rail for long transport of containers; increasing use of renewables for shipping; phasing out internal-combustion vehicles; creating the charging infrastructure for all-electric vehicles; converting heavy transport vehicles to hybrid power or hydrogen fuel cells; producing biofuel (methane) from solid and sewage waste; adapting ecological practices for manufacturing[29].

- **Preventive** (complete, sustainable energy-related policies): building on the adaptive and mitigative policies to bring the atmospheric heat balance to equilibrium; returning to sustainable agriculture and forest management; phasing out carbon combustion; cutting excess consumption; near complete waste reduction, reusing, recycling; further developing diverse and well-distributed renewable energy sources including waste-to-energy biofuel, wind and tide, solar-hydrogen as a primary source.

To enact these policies, we need to quickly garner sufficient public and political will in combination with the best uses of our scientific & technical knowledge. Important requisites to this effort would be:

1) To gain universal recognition that our present business-as-usual approach is leading us in the wrong direction.
2) To transform our governance to one capable of addressing CC and CG issues.
3) To transform present capitalist economies into sustainable ones that include self-regulating controls and macroeconomic decisions based on social need and environmental sustainability. This transition requires that we conduct balanced assessments of all capital: financial, environmental, and social. That is, the new economy should internalize social and environmental capital as values instead of externalizing
4) To transform our energy source to renewables and the energy infrastructure to a shared space-free nodal distribution system.
5) To connect policymakers to a comprehensive scientific framework that can assist in evaluating options for implementing the most efficient sequence of policy strategies needed for sustainability.

2.2c. Ongoing Situation. The changes occurring in the atmosphere, in the ocean, and on Land indicate that the atmosphere is already undergoing a self-organization that will further affect our planetary and societal systems regardless of whether we sit back and let it happen or not. On a decadal scale, it is still difficult to predict a business-as-usual scenario, because of the uncertainty in important interactions between atmospheric change and the three others Earth-Systems that are themselves very complex and interactive. Presently, the biggest uncertainty is the human interaction with the atmosphere: the question of how and when we are going change our activities. That is, will we continue crisis management or initiate a precautionary, prioritized systems approach?

> Our biggest uncertainty is whether or not we can generate a wise management plan from our governments that currently can't find the off-valve.

Including the interactions between the Earth Systems in expanded climate models is now a high priority and an absolute necessity so that we can better anticipate and respond to the impacts of CC. To reduce the uncertainty in such Earth System Models[30] (EaSM) they need input from sophisticated monitoring of real-time data so that the models' dynamics can be made more accurate. For good decisions to be made about the response to CC impacts, the capacity to test policy options must be included in or linked to the EaSM. Obviously, this must be a global effort to achieve greater accuracy and to realize more efficient collective action. It must also lead to modeling of other environmental and social issues connected to CC. The United

Nations and other international organizations (such as the IPCC) are contributing essential information by tracking global trends and airing them in summit meetings.

2.2d. UN Commitment to Climate Change. At the United Nations Summit conference on August 15 in New York, the member nations approved by consensus the post-2015 development agenda: entitled: □" Transforming Our World: The 2030 Agenda for Sustainable Development."[31] This comprehensive Document represents a UN commitment to Sustainable Development by setting sustainable-development goals to be met by 2030 together with guidelines for their implementation and progress monitoring (cf. Chap. 5, E.4). This document became known as the "Paris Agreement" and was subsequently adopted by the UN Framework Convention on Climate Change[32] (UNFCCC) held in Paris, December 2015. The UNFCCC had a priority focus on the thirteenth goal concerning Climate Change, to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". All 196 parties attending adopted the final document by consensus, thus providing a first precedent for complete Global Consensus and Cooperation, which in this case concerns a global goal of Sustainable Development and for immediate action on Climate-Change issue.

With its consensus on the Paris Agreement, the UN renewed its commitment to an expansion of the previous eight Millennium Development Goals (MDGs) and made them more comprehensive by adding another nine for a total of seventeen Sustainable Development Goals for 2030. See Chap. 5, E.1, and E.4 for more description.

However, under present conditions, these UN efforts cannot accomplish these goals. Lacking the required authority, they cannot comprehensively address the root causes (Fig. 2) needed to commit to a sustainable transformation of global economies and governance. Discussion of this type of commitment is not even on the political horizon of most MDCs and DCs. For example, the United States, which has been the greatest contributor to CC, is only recently initiating a restrictive leadership role[33], but its actions are not yet concomitant with its responsibility for the CC or GC problems.

An example of this is the administration's licensing Royal Dutch Shell to drill for oil in the Arctic Ocean even while the President was talking about the urgency of addressing CC during a visit to Alaska (fortunately, Shell decided the project was not cost-effective and abandoned it). Achieving this leadership will require a coordinated effort of the social, economic, and political sectors; but this has not yet begun. Also, important will be the additional cooperation needed between the global scientific community, the public, and those political-industrial alliances that ultimately have the vested power to implement the changes needed. By not taking strong systematic action, the US government is failing to implement preventive strategies for CC resolution. Unless the government takes such action, the result will be an exponential increase of future costs far in excess of the present costs of continuing a delayed response with weak strategies.

2.2.d Some Adaptive Actions in the US. The Citizens Climate Lobby[31] is advocating a revenue-neutral carbon tax that would exert market pressure to shift away from FF. This can be done with no cost to the public by returning the corresponding price increases at the pump as an IRS income tax deduction, thereby avoiding additional bureaucratic administration for its implementation. The tax would increase in time in order to deter the FF industry from 'writing it off' as a business expense, and it would generate a high public visibility by better reflecting the 'real' in

price of carbon. As a simple adaptive action, it offers an intelligent start-up strategy to serve as a catalyst for the strategy for CC resolution.

The non-profit 350.org[34] is a bottom-up popular movement focused on solving the climate crisis through online campaigns, grassroots organizing, and mass public actions that are coordinated by a global network active in over 188 countries. Their focus is to make global leaders responsible "*to the realities of science and the principles of justice*". 350.org groups are active in hundreds of local campaigns around issues like preventing oil trains from running through heavily populated areas, stopping or preventing fracking, fighting against oil and coal exports, and so on.

The Climate Reality Project[35] is another powerful movement that is fostering climate leaders to help educate and guide public awareness of how the climate-change crisis affects their lives and how they can contribute to its resolution. Other movements advocate divestment from fossil fuels[36] on the moral grounds that "*If it is wrong to wreck the climate, then it is wrong to profit from that wreckage. We believe that educational and religious institutions, city and state governments, and other institutions that serve the public good should divest from fossil fuels. We want institutions to immediately freeze any new investment in fossil fuel companies, and divest from direct ownership and any commingled funds that include fossil fuel public equities and corporate bonds within 5 years*." They specifically demand that publicly traded fossil-fuel companies immediately:

1) Stop exploring for new hydrocarbons
2) Stop lobbying in Washington and state capitols across the country to preserve their oil assets,
3) Pledge to keep 80% of their current reserves underground forever; and
4) Begin working with the governments to transition our energy sources and their distribution networks for renewable energy.

By September 2014, 181 institutions and 656 individuals had committed to divest over $50 billion worth of fossil-fuel reserves. This movement is creating a carbon bubble for fossil-fuel assets, which constitutes a major threat to the viability of fossil-fuel enterprises and stability of the market. The price of fossil-fuel assets is valuated on the basis that the known extractable reserves will eventually be consumed, which would release to 2.8 trillion tons of CO_2. The current best estimate of the amount of CO_2 that we can emit by 2050 to stay within the 2° C limit is only 0.5 trillion, or about 20% of this total, most (about 80%) of which would come from coal reserves[37]. Hence the true costs of carbon dioxide in intensifying global warming is not taken into account in a company's stock market valuation. Citigroup predicts $100 trillion of stranded petroleum assets if the 2015 Paris Climate Summit succeeds[38].

A growing GDP is not compatible with cutting GHG emissions

The many CC groups are indicators of the type of bottom-up organizations that are emerging to increase public awareness of the CC issue. However, it will take an integration of all environmental and social movements to force global leaders to address the paradigm changes and phase shifts that that will eventually be needed. That these will be extremely difficult is no excuse for not starting immediately, as in the 2015 December Summit. Until we transform our consumptive economy to a sustainable one, are losing all options for CC resolution. Critically missing is a strong movement for sustainable development with a sustainable economy. Once we dedicate ourselves to sustainability, the integration all of these supportive movements will have a greater apparent value and mission. As such they can catalytically cause a constructive, cycle of self-organization towards sustainable energy use and infrastructure, towards a green economy, and towards a public consensus for investing in our long-term wellbeing.

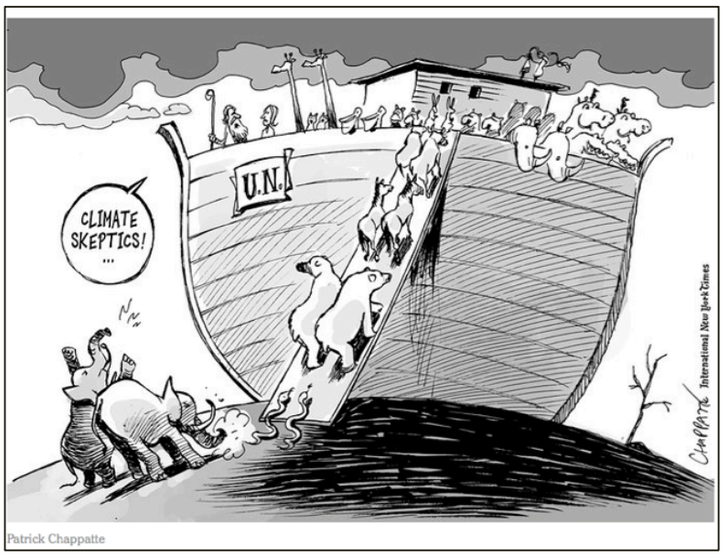


Fig. 5a Yeah, and you know, now we won't have to be rich to belong! (NYT).

Fig. 5b Should we have pity for Climate-Change Deniers? (NYT, 17 Jan 14)

Section A endnotes

[1]

[2] **Global Footprint Network.** *Advance the Science of Sustainability.* www.footprintnetwork.org/

[3] **Global Footprint Network.** *Advance the Science of Sustainability.* www.footprintnetwork.org/

[4] **Nuclear War.** For this discussion, we exclude nuclear war, which would be of similar scale, but would cause even greater damage, and would also generate additional impacts to global climate as a possible final consequence will not be discussed for obvious reasons.

[5] **United Nations**. 2013. *The millennium development goals report.* United Nations, New York, New York, USA. http://www.un.org/millenniumgoals/

[6] **Capra, F**., 1996. The Web of Life, HarperCollins Publishers, Hammersmith, London. pp 320

- Throughout this text, we will use the word **self-organization** to refer to the reorganizational process that systems undergo in recovering from sudden stresses or damaging trends.

[7] **Hopkins, T. S.,** 2001. *Scientific Concepts and Global Problems*. North Carolina State University, Department of Marine, Earth, and Atmospheric Sciences Course Pac MEA 430, 172 pp.

[8] **Ibid. # 3**

[9] **Credit Suisse**, Research Institute's "Global Wealth Databook", published 2013

[10] **Ibid. #13**

[11] **Ibid. #6**

[12] **Convention on Biological Diversity. 1992.** https://www.cbd.int/doc/legal/cbd-en.pdf

[13] **Residence time** is a term used to estimate the average length of time of a substance remains in a reservoir or system. For example, the length of time CO_2 molecule emitted from a vehicle remains in the atmosphere. Its residence time depends on how and where it enters the atmosphere, and how it reacts chemically in the atmosphere, leaves the atmosphere, or how quickly it is absorbed by land or water. For this reason, its average time can only be estimated. See https://en.wikipedia.org/wiki/Greenhouse_gas#Atmospheric_lifetime.

[14] **EPA Air Pollutants** http://www.epa.gov/air/airpollutants.html

[15] **Interglacial Optimum period –** The period when the northern hemisphere gets maximum exposure to sunlight within the Milankovic Cycles. https://en.wikipedia.org/wiki/Interglacial#

[16] **Hopkins, T.S. D. Bailly, R. Elmgren, G. Glegg, A. Sandberg, J. Støttrup.** 2012. A Systems Approach Framework for the Transition to Sustainable Development: Potential Value based on Coastal Experiments. In: Ecology and Society Special

Feature Volume, **16**
(4) http://www.ecologyandsociety.org/

- **Fiksel, J. 2006. Sustainability and resilience: toward a systems approach.** ***Sustainability: Science, Practice, & Policy*** **2 (2):14-21. [online] URL: http://sspp.proquest.com/archives/v ol2iss2/0608-028.fiksel.html**

[17] **Sierra Club**, http://www.sierraclubfoundation.org/node/158

[18] **International Panel on Climate Change, (IPCC), http://www.ipcc.ch/organization/organization.shtml**

[19] **Precautionary Principle.** Listed among the 27 Principles to guide sustainable development of the Rio Declaration. h**ttps://en.wikipedia.org/wiki/Rio_Declaration_on_Environment_and_Development**

[20] **Earth Summit, 1992.** US becomes a signatory country to Agenda 21 https://en.wikipedia.org/wiki/Agenda_21

[21] **The 2012 Republican Platform.** The Republican Party Committee https://cdn.gop.com/docs/2012GOPPlatform.pdf

[22] **ICLEI** -Local Governments for Sustainability. http://www.iclei.org

[23]**Ibid. #25**

[24] **A Systems Approach Framework for Coastal Zones. 2011, Hopkins, T. S., D. Bailly, and J. G. Støttrup. 2011.** A systems approach framework for coastal zones. *Ecology and Society* 16(4): 25.http://dx.doi.org/10.5751/ES-04553-16042

[25] **Earth Systems Models,** http://www.gfdl.noaa.gov/earth-system-model

[26] **Hopkins T.S.** and **D. Bailly** 2012. The role of science in the transition to sustainability: the systems approach framework for integrated coastal zone management. In: E. Moksness, E Dahl, and J Støttrup, editors. *Integrated coastal zone management.* 2nd edition. Wiley-Blackwell.

[28] **Citizens' Climate Lobby, www.citizensclimatelobby.org**

[29] **Industrial Ecology 2nd Edition. 2010.T. E. Graedel, B. R. Allenby.**

[30] **Ibid. # 30**

[31] **https://sustainabledevelopment.un.org/post2015/transformingourworld**

[32] **120815 outcome-document-of-Summit-for-adoption-of-the-post-2015-development-agenda.pdf.**

[33] **US leadership for Climate Change and other GC** is restricted by the current Congress, which would undoubtedly continue if the opposition party remains after 2016 elections.

[34] **The 350.org movement.** http://350.org

[35] **Climate Reality Project.** https://www.climaterealityproject.org

[36] **Fossil Free,** *Divesting from Fossil Fuels*. **gofossilfree.org**

- **Fossil fuel divestment: a brief history**. *www.theguardian.com*. The Guardian. Retrieved 26 February 2015.

[37] **Wikipedia**, https://en.wikipedia.org/wiki/Fossil_fuel_divestment.

[38] **CitiGroup,** RenewEconomy, 25 August 2015

A.2. Climate Change

2.1 Defining the Issue

2.1a Earth Systems. In this document, we will make frequent reference to systems and their characteristics. A system is an integrated set of processes that has a definable function. The adjective 'complex' emphasizes that a system can change its function, composition, and structure through a self-organizational process stimulated by its internal interactions between its subsystems, or by interactions with externally connected systems. For this discussion, we will represent the Earth System as composed of four major subsystems: the natural systems (Terrestrial, Marine, Atmospheric, plus the emergent Human system, often referred to as 'Anthropic' (Fig. 6). Each of these subsystems is composed of networks of smaller component systems.

2.1b Systems Perspective. A characteristic of complex systems is that their equilibrium is sensitive to both external and internal disturbances. When two systems are dynamically coupled, a disturbance in one system can create disturbances in the other system. Each system has levels of resilience that allow them to recover their equilibrium, or not, from internal or external disturbances. Systems, including the internal systems of organisms, recover through feedback loops, e.g. as our immune system does from a cold after exposure to germs. However, if local external disturbances exceed the resilience capacity of a living species for a long enough time, and if it can't migrate to a better environment, it will perish. Our current excessive rates of species extinction are due to human disturbances weakening the resilience of plants and animals through habitat destruction, changing climate, increasing pollution, and overharvesting. Efforts to conserve biodiversity[39] equate to efforts to conserve resilience, which translates to an essential factor in our transition sustainable management of ecosystems.

With regard to Climate Change, the human system is disturbing the atmosphere with GHG emissions, chiefly carbon dioxide, methane, and nitrous oxide. As the upward trend in emissions continues, the inter-system disturbances will continue to increase in intensity and complexity in a manner mostly unfavorable to the three Natural systems. Since the initial human disturbance is a continuing trend and not just an event (as a large volcanic eruption), the atmosphere must continue to internally adjust, and likewise so must the marine and terrestrial systems. That is, as these systems surpass their resilience thresholds, they adjust through a self-organizational feedback process to a more highly entropic state (that is, degrade to a less complex and less ordered state). Important examples of such changes in Earth Systems due to climate change are:

- The northern **atmosphere** changes its polar circulation—because its boundary (the Polar Sea) changes from ice to water, which exposes the surface water to evaporation. This warms and humidifies the air, making it less dense, causing it to rise and thereby disturb the vertical structure of the polar vortex, which in turn slows and expands the jet stream's north-south oscillations. This both unusually warm and cold weather patterns in the sub-polar and mid-latitudes.
- The **marine** trophic changes—because as atmospheric CO_2 increases, more of it is dissolved in the ocean. This makes the water more acidic, which then renders the ocean less able to support organisms that use calcium carbonate, such as corals, shellfish, and some phytoplankton species.
- **Terrestrial** ecosystems and agriculture change—because they cannot adapt to the rates of warming temperatures and changing rainfall patterns.

These climate-change impacts are acting to weaken important aspects of the Human system's resilience, because the supporting Earth systems are losing their resilience and becoming less stable relative to their original equilibria. In other words, as the three Earth systems continue to lose their resilience, we are losing plant and animal species, and their functionality; we lose the biocapacity that we depend on.

Ironically, the most important loss of our resilience comes from our inability to respond to the CC disturbance and to confront its root and intermediary causes of overconsumption, neglect of resource value, emissions, bad land-use,. A non-response on the part of the human system would constitute a 'positive feedback' (enhancing the disturbance), whereas human actions that counter the disturbance would constitute a 'negative' feedback (quelling the disturbance). For example, if we don't like the way the climate is responding to our disturbance (GHG emissions), we could respond with a negative feedback (cut off the emissions) such that the atmosphere would gradually tend to return to its normal equilibrium (with normal interactions). Unfortunately, this may not be the case if the atmospheric dynamics have already changed to accommodate the increased levels of GHGs. In other words, if we could immediately turn off the causal CO_2 emissions, the average amount of CO_2 accumulated in the atmosphere would decrease slowly because CO_2 has average residence time of 30-95[40] yrs. However, the CC disturbances would continue while the excess accumulation exists because the severity of CC impacts also depends on the duration of that persistence. In addition, many of the CC impacts are strongly linked to CC; for example, reduced ice cover lowers the amount of heat reflected back to space. Consequently, when the CO_2 accumulation starts to lessen, it will recede more slowly than it would have if the CO_2 absorption capacity of the earth's surface had remained at its starting point (cf. Chap 6). In sum, the CC impacts won't shut off immediately, will weaken slowly, and will differ in effect, in accordance with a new equilibrium between the four earth systems.

We cannot guarantee the recovery of the historic equilibria of the Earth, Atmospheric, Marine, and Terrestrial Systems.

Thus, a focus on cutting emissions is only part of the solution to returning to acceptable levels of GHGs. An even greater challenge is that of restoring the absorption capacity of the marine and terrestrial systems. By itself, the recovery of the atmospheric system would not ensure elimination the CC impacts, especially those for which the dynamics controlling the interactions between the atmosphere and the marine and terrestrial systems have changed irreversibly on a longer-than human time scale, e.g. the glaciers may not return, the sea level won't go down, forest ecosystems may not recover. Furthermore, the complexity of the recovery processes suggests additional uncertainties that many of the CC impacts may not return to their previous levels of intensity.

These complex uncertainties bear directly on how quickly we respond to climate change, which in itself creates more uncertainty. There is still a risk that too many societies are hesitating to commit to sustainable development. That is, the uncertainties and the lack of understanding of the urgent need generates a fearful perception that the situation is impossible and that changing to sustainable solutions is more frightening than the consequences of not committing to them. This brings us back to the need for public awareness of these GC impacts and the knowledge that they are threatening the entire planetary habitat and consequently impacting all humans, even those who are not responsible for causing them. Concurrently important is the conviction that we must not be passive and that we must remember that the

Human system has an advantage over the other Earth systems: consciousness and the ability to consciously self-organize as well as to transform the material basis of our societies by changing both core technologies (energy generation, agriculture, transportation) and core social relationships. Only we can save ourselves, in other words, with our superior intelligence and a consciousness that allows us to act deliberately to save our habitat and not have to wait for some genetic adaptation to a changed planet.

2.1c. The Role of Climate Change in the Global Change. Climate Change is caused directly by overconsumption and indirectly by overpopulation in the form of an excess of GHGs emitted into the atmosphere that the altered marine and terrestrial systems are less able to absorb. On both temporal and spatial scales, CC is the largest contributor to our excessive ecological footprint (Fig. 1). Its widely diverse impacts aggravate other major man-made problems (Fig. 2). The continuing increase in GHG emissions forces an extreme urgency for humans to respond. Of great importance for us to remember also is that the GHGs and other air pollutants (cf. EPA listing[41] are intermediary causes responsible for CG and CC. As shown in Fig. 2, the primary controls that are mismanaging our society are our economy, governance, and culture. Any CC strategy that fails to recognize this will fail – as explained in later Chapters.

Fig. 6 A pictorial representation of the major components of the Earth's complex system with the Marine, Terrestrial, Atmospheric, and Human subsystems and their two-way connections. The three natural subsystems have evolved to interact with each of the others in such a way as to maintain a balanced equilibrium governed by the energy input of the sun. This equilibrium has evolved over a long history of change to its present form, which has maintained a balance despite significant variations in each of the subsystems and in the sun's radiation. The human system has emerged from an insignificant portion of earth's biological system to a uniquely significant subsystem that has greatly increased its interactions with each of the three natural systems (colored arrows). As a result, these natural systems are losing their resilience, and the human system is losing the quality and quantity of the goods and services that humans demand from the natural systems. [Author generated].

Climate Change plays two critical roles in our global transition to a sustainable, safe condition. On the negative side, CC acts to amplify the other Global Change problems. On the positive side, the approach needed to resolve CC should serve as a prototype strategy for resolving the other global problems. In other words, the approach and strategies needed to reverse CC overlap with those needed to resolve the other Global Change problems, many of which are both contributing to and aggravated by CC.

The fact that CC has a very long reversal time acts to extend the reversal time of those GC impacts that are dynamically connected with CC. Some examples of GC impacts for which the non-resolution of CC is extending reversal times are: the salinization of ground water in coastal aquifers, the desertification of grazing lands, and the acidification of the ocean,. Without immediate effective action, preventive reversal of some other GC impacts will likely extend far beyond the human time scale to that of hundreds or thousands of years, e.g. sea level, ice cover, biodiversity, and even persistence of the human species. Note that all bets are off at the millennial scale when the planet is scheduled to return to an ice-age due to less sunlight in the northern hemisphere as the earth ends its "interglacial optimum period."[42]

The complexity of these connections between CG impacts (Fig. 2) implies that the scientific work, international political cooperation, and national policies needed to solve CC will bear significantly on the resolution of the other global trends. It also implies that we must use a systems approach[43] that employs model simulations in a transdisciplinary framework composed of natural and social sciences working in tandem with the public and policy stakeholders (cf. Chap 5). Unfortunately, many in the US feel that we would be giving up our sovereignty by working in cooperation with the UN on CC. In reality, we would gain an essential collaborator and connections with the community of nations. A most important example where this framework is needed is in devising our best response to CC, which should begin by phasing out fossil fuel combustion and phasing in a transition to renewable energy from other sources. In Europe and in the US, this transition is already well underway, in large part due to the tireless efforts of a growing number of climate activists. For example, the Sierra Club[44] has been able to block the construction of over 400 new coal-fired power plants since the turn of the century. But the transition is still largely unsupported by government action and it is not proceeding fast enough to counter the rapid growth in GHG emissions from large MDCs like China, India, and Brazil as they urbanize.

2.2 Finding our Response

2.2a. Current Situation. For the last several decades, it has been difficult for the public to accept is that CC is already happening and that it will continue to increase in intensity and uncertainty. This difficulty holds equally for the policymakers who have wanted up-front predictions of risks and damage costs before committing to action. Initially, it was difficult for scientists to make defensible predictions due to a lack of data to valid their models. However, in the 1980s, trends in environmental parameters were becoming significantly different than their long-term averages, e.g. in CO_2 concentrations, sea level, air temperature, glacial melt, etc. These data allowed scientists to more accurately model extrapolations from which they could provide reasonable predictions with fewer uncertainties.

Our enemy is not CO_2, but our management system that can't find the off valve

In 1992 the Intergovernmental Panel on Climate Change[45] (IPCC) issued its First Assessment Report confirming that the atmospheric greenhouse effect was increasing due to excess emissions of GHG. In that same year, the UN Earth Summit issued its guide of 27 Principles relevant to Sustainable Development[46], one of which was that States should abide by the Precautionary Principle: i.e. "*Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*." Twenty-three years and much more accurate predictions later, the need for precautionary action is all the more urgent and justified. In 1992, George H. Bush signed the final text making the US a signatory to Agenda 21[47]. Since Agenda 21 was a legally non-binding statement, Congress was not required to debate it as if it were a treaty. It has remained much too controversial to pass approval in Congress, with the opposition arguing that it is "erosive to our sovereignty"[48] In contrast, 528 US cities have become members of ICLEI (Local Governments for Sustainability[49] that helps to implement the Agenda 21 and its concepts.

Two decades later, the internal adjustments of the atmosphere have become obvious, notably through changes in its circulations that now distribute greater excess heat and water vapor poleward in the form of more intense storms dispersed over larger geographic areas. These same atmospheric changes are driving changes in the Marine, Terrestrial, and Human systems. The ocean's equilibrium state is experiencing abnormal changes in its heat storage, its carbon balance, and its surface ice coverage, each of which drives further changes in ocean circulation, sea level, acidity, biological populations, and exchanges with the atmosphere. Likewise, the terrestrial system is also put in disequilibrium by these atmospheric changes, manifested by floods, droughts, loss of biodiversity, glacial melting, earthquakes, and unseasonal weather that in turn disturbs microbial, insect, plant, animal, and human populations. All of these changes bear on the biocapacity that humans depend on. If human activities were properly coupled to the three Earth systems, humans could self-regulate these activities in response to these impact signals and thereby sustain their equilibria. Instead the majority of the human population is still uninformed, in denial, or in opposition, and is not demanding a proactive and effective response, and hence allowing the impacts to increase. The US Republican Party platform, for example, criticizes the President for having raised the security risk status of CC to the highest level, that is, equivalent to the threat of foreign military aggression (an assessment backed by the defense Department!)[50].

2.2b. Confronting Climate Change. The options for humans in response to these signals are panicking, adapting, mitigating, or preventing (Fig. 7). Prevention means eliminating the causal conditions in order to allow the three earth systems to establish new interdependent equilibria. There is no guarantee that any of the systems would exactly replicate its historic equilibrium, because the changes that have occurred are not always or exactly reversible and because the initial conditions for the reversal in each case would be different. For example, a previously dominant species that has been weakened may not regain its dominance, the previous ice cover of the Arctic Ocean and polar atmospheric circulation may not recover, or the desertified grasslands of the continents may not become re-established.

Examples of immediate mitigative CC actions that would significantly help stabilize climate are a roughly 80% reduction of total GHG emission sources and similar improvements in the land process for CO_2 absorption sinks. If both of these actions were quickly and resolutely taken, the eventual new equilibria of the three natural systems might be closer to the historic ones. Meanwhile adaptive strategies would be

needed to conserve and assist vulnerable areas and populations. Concurrently and most importantly would be a first-order focus on preventive solutions to CC. Obviously, these actions will require large and difficult changes, but they will result in reducing our present ecological footprint and in restoring the biocapacity supporting it. However, achieving these goals will concurrently require changing to a sustainable economy, more representative governments, and global collective cooperation agreements (cf. Chap. 4 & 5).

Because of the complexity of CC, let alone that of CG, it is of paramount importance that we confront the CG issues in a holistic and systematic manner to minimize mistaken or poor policies. This raises a catch-22 dilemma that the needed new policies must be carried out by and through the projected new sustainable economy and modified sustainable government. An integrated systems approach framework[51] can best cope with such a dilemma (cf. Chap. 5 & 6). To minimize ineffective policy decisions, policy options are first simulated and sorted into a synergistic sequence. This sorting matrix will involve parameters of urgency, importance, difficulty, risk, and valuations of costs and benefits based on inclusion of all three capitals. Basically, it will involve immediate adaptive policies that are straightforward and can act as constructive precursors for the more complex policies that have large risk factors, such as protecting populated coasts. The shift to focus on more complex or difficult policies must also begin immediately (model development) so that they can provide a graduated set of scenarios for policy options for mitigation policies that can support the essential preventive strategies that must eventually be enacted. The NOAA Earth Systems Model[52] is a valuable example of iterative simulations of scenario results.

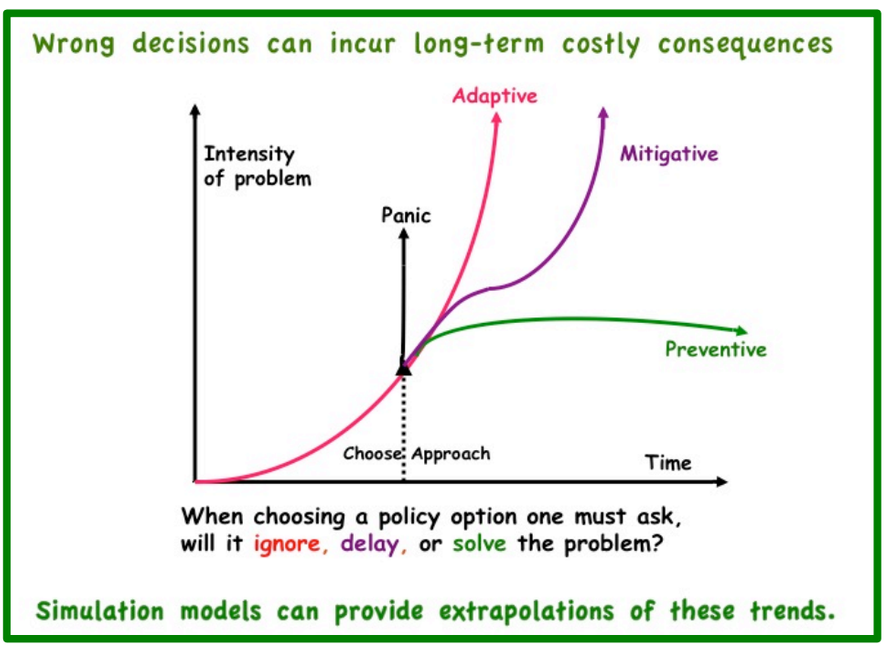


Fig. 7 There are four ways that we can respond to impacts: Panic (wrong response), Adaptive (live with it), Mitigative (lessen its effect), and Preventive (eliminate its cause). Rarely are problems static in dynamic systems: some change is inevitable. If the impact is increasing, it is important to select as high a level of response as feasible; and if not, to select one that can be upgraded, e.g., from mitigative to preventive. Methodology exists for simulating their trajectories relative to different management options, so as to guide management[53].

A sustainable energy plan must be inclusive of CC. In other words, the actions we take to resolve the CC issue must be building blocks of a sustainable energy plan, and vice versa. This plan would proceed with priority adaptive strategies that can be carried out with current management, meanwhile initiating feasible mitigative strategies

that are at least feasible with an improving management and compatible with preventive strategies that require a transformed management. All practices must be designed to facilitate upgrades, and the total process evolves. Some (non-prioritized) examples of this sequence relative to the CC issue of strategies would be:

- **Panic** (maintaining unsustainable policies): Subsidizing oil and coal energy production; promoting industrial agricultural practices; not honestly explaining to the crisis to the public; continuing excessive consumption, not making the CC issue a national security priority.
- **Adaptive** (resilience-building policies): Imposing a gradually increasing carbon fee on FF sources[55]**;** divesting from FF equity assets; cutting carbon combustion; conserving energy by all means available; explaining to the public the need for and benefits of sustainable development; promoting the transitions of agriculture, industry, transportation, and power-generation to greater robustness and sustainability; protecting the coasts against sea-level rise,.
- **Mitigative** (infrastructure policies): Transforming the energy infrastructure for renewable energy; phasing out coal and unconventional petroleum (shale, tar, and gas fracking, and agriculture biofuel); redesigning buildings for energy conservation; modernizing local and national rail; encouraging installation of photovoltaics on buildings; re-designing the electrical grid for local generation; using rail for long transport of containers; increasing use of renewables for shipping; phasing out internal-combustion vehicles; creating the charging infrastructure for all-electric vehicles; converting heavy transport vehicles to hybrid power or hydrogen fuel cells; producing biofuel (methane) from solid and sewage waste; adapting ecological practices for manufacturing[56].
- **Preventive** (complete, sustainable energy-related policies): building on the adaptive and mitigative policies to bring the atmospheric heat balance to equilibrium; returning to sustainable agriculture and forest management; phasing out carbon combustion; cutting excess consumption; near complete waste reduction, reusing, recycling; further developing diverse and well-distributed renewable energy sources including waste-to-energy biofuel, wind and tide, solar-hydrogen as a primary source.

To enact these policies, we need to quickly garner sufficient public and political will in combination with the best uses of our scientific & technical knowledge. Important requisites to this effort would be:

1. To gain universal recognition that our present ‘business-as-usual’ approach is leading us in the wrong direction.
2. To transform our governance to one capable of addressing CC and CG issues.
3. To transform present capitalist economies into sustainable ones that include self-regulating controls and macroeconomic decisions based on social need and environmental sustainability. This transition requires that we conduct balanced assessments of all capital: financial, environmental, and social. That is, the new economy should internalize social and environmental capital as values instead of externalizing them.
4. To connect policymakers to a comprehensive scientific framework that can assist in evaluating options for implementing the most efficient sequence of policy strategies needed for sustainability.

2.2c. Ongoing Situation. The changes occurring in the atmosphere, in the ocean, and on Land indicate that the atmosphere is already undergoing a self-organization that will further affect our planetary and societal systems regardless of whether we sit back and let it happen or not. On a decadal scale, it is still difficult to predict a business-as-usual scenario, because of the uncertainty in important interactions between atmospheric change and the three other Earth-Systems that are

Our biggest uncertainty is whether or not we will have wise action from our governments that currently can’t find the off-valve.

themselves very complex and interactive. Presently, the biggest uncertainty is the human interaction with the atmosphere: the question of how and when we are going change our activities. That is, will we continue crisis management or initiate a precautionary, prioritized systems approach?

Including the interactions between the Earth Systems in expanded climate models is now a high priority and an absolute necessity so that we can better anticipate and respond to the impacts of CC. To reduce the uncertainty in such Earth System Models[57] (EaSM) they need input from sophisticated monitoring of real-time data so that the models' dynamics can be made more accurate. For good decisions to be made about the response to CC impacts, the capacity to test policy options must be included in or linked to the EaSM. Obviously, this must be a global effort to achieve greater accuracy and to realize more efficient collective action. It must also lead to modeling of other environmental and social issues connected to CC. The United Nations and other international organizations (such as the IPCC) are contributing essential information by tracking global trends and airing them in summit meetings.

2.2d. UN Commitment to Climate Change. At the United Nations Summit conference on August 15 in New York, the member nations approved by consensus the post-2015 development agenda: entitled: □" Transforming Our World: The 2030 Agenda for Sustainable Development."[58] This comprehensive Document represents a UN commitment to Sustainable Development by setting sustainable-development goals to be met by 2030 together with guidelines for their implementation and progress monitoring (cf. Chap. 5, E.4). This document became known as the "Paris Agreement" and was subsequently adopted by the UN **Framework Convention on Climate Change**[59] (UNFCCC) held in Paris, December 2015. The UNFCCC had a priority focus on the thirteenth goal concerning Climate Change, to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". All 196 parties attending adopted the final document by consensus, thus providing a first precedent for complete Global Consensus and Cooperation, which in this case concerns a global goal of Sustainable Development and for immediate action on Climate-Change issue.

With its consensus on the Paris Agreement, the UN renewed its commitment to an expansion of the previous eight Millennium Development Goals (MDGs) and made them more comprehensive by adding another nine for a total of seventeen Sustainable Development Goals for 2030, se (Ch. 5) for more description.

However, under present conditions, these UN efforts cannot accomplish these goals without sufficient cooperative sharing they cannot comprehensively address the root causes (Fig. 2) needed to commit to a sustainable transformation of global economies and governance. Discussion of this type of commitment is not even on the political horizon of most MDCs and DCs. For example, the United States, which has been the greatest contributor to CC, is only recently initiating a restrictive leadership role[60], but its actions are not yet concomitant with its responsibility for the CC or GC problems.

An example of this is the US administration's licensing Royal Dutch Shell to drill for oil in the Arctic Ocean even while the President was talking about the urgency of addressing CC during Shell Oil's visit to Alaska. Fortunately, Shell decided the project was not cost-effective and abandoned it, only to have the incoming US administration trying to open up not only the Arctic but the entire US offshore waters for drilling.

Achieving this leadership to address the root causes and loose governance controls will require a coordinated effort of the social, economic, and political sectors; but this has not yet begun. Also, important will be the additional cooperation needed between the global scientific community, the public, and those political-industrial alliances that ultimately have the vested power to implement the changes needed. By not taking strong systematic action, the US government is failing to implement preventive strategies for CC resolution. Unless the government takes such action, the result will be an exponential increase of future costs far in excess of the present costs of continuing a delayed response with weak strategies.

2.2.d Some Adaptive Actions in the US. The Citizens Climate Lobby[31] is advocating a revenue-neutral carbon tax that would exert market pressure to shift away from FF. This can be done with no cost to the public by returning the corresponding price increases at the pump as an IRS income tax deduction, thereby avoiding additional bureaucratic administration for its implementation. The tax would increase in time in order to deter the FF industry from 'writing it off' as a business expense, and it would generate a high public visibility by better reflecting the 'real' in price of carbon. As a simple adaptive action, it offers an intelligent start-up strategy to serve as a catalyst for the strategy for CC resolution.

The non-profit 350.org[61] is a bottom-up popular movement focused on solving the climate crisis through online campaigns, grassroots organizing, and mass public actions that are coordinated by a global network active in over 188 countries. Their focus is to make global leaders responsible "*to the realities of science and the principles of justice*". 350.org groups are active in hundreds of local campaigns around issues like preventing oil trains from running through heavily populated areas, stopping or preventing fracking, fighting against oil and coal exports, and so on. The Climate Reality Project[62] is another powerful movement that is fostering climate leaders to help educate and guide public awareness of how the climate-change crisis affects their lives and how they can contribute to its resolution.

Other movements advocate divestment from fossil fuels[63] on the moral grounds that "*If it is wrong to wreck the climate, then it is wrong to profit from that wreckage. We believe that educational and religious institutions, city and state governments, and other institutions that serve the public good should divest from fossil fuels. We want institutions to immediately freeze any new investment in fossil fuel companies, and divest from direct ownership and any commingled funds that include fossil fuel public equities and corporate bonds within 5 years*." They specifically demand that publicly traded fossil-fuel companies immediately:

1) Stop exploring for new hydrocarbons
2) Stop lobbying in Washington and state capitols across the country to preserve their oil assets,
3) Pledge to keep 80% of their current reserves underground forever; and to begin working with the governments to transition our energy sources and their distribution networks for renewable energy.

By September 2014, 181 institutions and 656 individuals had committed to divest over $50 billion worth of fossil-fuel reserves. This movement is creating a carbon bubble for fossil-fuel assets, which constitutes a major threat to the viability of fossil-fuel enterprises and stability of the market. The price of fossil-fuel assets is valuated on the basis that the known extractable reserves will eventually be consumed, which would release to 2.8 trillion tons of CO_2.

A growing GDP is not compatible with cutting GHG emissions

The current best estimate of the amount of CO_2 that we can emit by 2050 to stay within the 2˚ C limit is only 0.5 trillion, or about 20% of this total, most (about 80%) of which would come from coal reserves[64]. Hence the true costs of carbon dioxide in intensifying global warming is not taken into account in a company's stock market valuation. Citigroup predicts $100 trillion of stranded petroleum assets if the 2015 Paris Climate Summit succeeds[65].

The many CC groups are indicators of the type of bottom-up organizations that are emerging to increase public awareness of the CC issue. However, it will take an integration of all environmental and social movements to force global leaders to address the paradigm changes and phase shifts that that will eventually be needed. That these will be extremely difficult is no excuse for not starting immediately, as in the 2015 December Summit. Until we transform our consumptive economy to a sustainable one, we are losing all options for CC resolution. Critically missing is a strong movement for sustainable development with a sustainable economy. Once we dedicate ourselves to sustainability, the integration all of these supportive movements will have a greater apparent value and mission. As such they can catalytically cause a constructive, cycle of self-organization towards sustainable energy use and infrastructure, towards a green economy, and towards a public consensus for investing in our long-term wellbeing.

C. Public Awareness.

C.1. Messages and Messengers.

1.1a Familiarity with Message. The signal of Climate Change is real and its causes are well established. Less known are the technical and policy solutions needed to eliminate these causes. The residual uncertainty surrounding the CC issue derives not from errors in the scientific evidence (as claimed by climate deniers) but from a lack of understanding of the problem. Without sufficient public familiarity and hence without political will for their reduction or elimination, our disturbances to the Earth's systems and their associated impacts will continue to increase. Acquiring this familiarity requires a learning process about an issue that is very different from historically reoccurring problems like war, poverty, endemic or pandemic disease, tyranny, and the like. In short, CC is an invisible, complex threat of a kind never before encountered. Unfamiliarity with the issue tends to make our response to it susceptible to misinterpretations and to obfuscations (concerning the type and the urgency of the responses needed by an individual or by a policy-maker (Chap. 3, Fig. 12).

The process of gaining familiarity has two tracks: one based on rational thought (scientific progression) and other on belief systems—cultural or faith convictions (see Chap. 5.5). In presenting an issue, one might start by trying to match one's information with the listener's belief system, or one might find a match with the listener's rational thought. However, a listener presented with a sequence of logical, fact-based arguments is likely at some point to lose connection with it and switch to an attempt to connect the arguments to his or her belief system, respectively. In short, complete communication is difficult because each person will have different thresholds for connection to rational explanations and to those relating to her or his belief-system, respectively. This is why a gradual and recurrent exposure to information from differing

perspectives is needed to ensure an acceptable level of familiarity with a complex issue. Clearly, the presenter must know the audience, understand the rational arguments, and be cognizant of the differing belief-systems of the audience on the topic (see Chap 5.5).

3.1b Messengers. In addition, there is the problem of the messengers describing the threats and its solutions. It is important to distinguish between the threats (the projected consequences already represented by observable facts) and the solution (how one would be involved in the resolution of the threat). Generally, science presents observable facts and how these facts are changing relative to some prior state, some already existing impact, or some rate of degradation: for example,: “OK, the sea level is rising, but how does that translate to 'When I will have to move my beach house?'” Science by itself is not given the responsibility to solve problems but can provide invaluable assistance regarding the technology needed, the cost, and the effectiveness of policy options for their solution. The message of messengers varies with distance from its origin:

1) The first-level messengers are the scientists who publish the evidence of change and its consequences in scientific journals, which are not generally read by the public. Those who wish to publicly deny the verity of scientific findings should provide scientifically derived evidence (not opinion) concerning which facts are supposedly in error.
2) The second-level messengers are those who have (or have not) come to believe in the scientific evidence and are trying to shift public opinion and policy. Believers (like, say, Al Gore or Bill McKibben) are generally activists who trust science and therefore want to spread information about CC impacts and their solutions and persuade both politicians and the public of the urgent need for action. Those who claim to be unconvinced, including a tiny minority of scientists and persons with a spurious scientific authority, work to persuade the public and elected representatives against taking any action on the issue.
3) Third-level messengers from the mainstream media and the blogosphere who are interpreting either or both of the previous messenger types then often further confound the public. Much of the emotional reaction towards CC derives from the uncertainty and fear concerning the changes one might have to make in one’s individual lifestyle.

Thus, the public is exposed to a mixture of these communications that tends to obscure the original information as scientifically demonstrated fact. This exposure often results in a reinterpretation of the information in the form of political controversy (in which the mainstream media simply present claims from both sides without evaluating them) such that much of the public is prone to dismiss the threat of CC until it becomes more apparent to them.

Through this muddle of information sources, the public gets a confused exposure to the in-depth factual aspects of CC’s potential impact on our society and its global connections. Consequently, the public lacks enough familiarity with the issue to judge the boundary between fact and fiction. Hence the public is worried about:

1) Political leadership being also confused and hesitant to decide on a plan of action;
2) Scientific facts supposedly being exaggerated in a self-serving manner to secure higher funding for researchers;
3) Whether traditional big energy companies will in fact shift away from fossil fuels;
4) The possibility that any solution will generate greater suffering and inconvenience due to the supposed CC threat.

Exploiting these and other similar concerns, climate deniers gain audience with those who are grasping for the hope that the issue is a false alarm. This level of confusion

promotes polarization and generates a poor social environment for decision-making. Therefore, the public dissemination of accurate knowledge about CC and its solutions must be given highest priority. In fact, this is already happening, as there exist already about 45 US based nonprofits alone with CC advocacy on their agendas[66].

3.1c Message to Policy. In a representative democracy, political questions should ideally be decided at the level of the individual voter, who chooses representatives based on their stated positions on these questions. However, social groupings of individuals composed of like-minded others can informally or formally sway an individual to vote with them. There are impartial means of improving this process through more in-depth airing, informing, discussing, and prioritizing solutions to important problems, such as those promoted by the League of Women Voters[67]. There are also many partial ways to intervene between the public and the policymaker. These vary widely in potency and motive, from special-interest groups, of which by far the most powerful are corporations institutes that can block legislation, (e.g. the American Petroleum Institute or the National Rifle Association), to organized groups of voters that advocate legislative reform on gun-issues, such as, labor-oriented groups, nonprofits, and commercial media that accepts payment (typically in the form of advertising revenue) for opinion-biased programs and announcements. These special interest groups and individuals also can influence the election by pushing a favorite candidate or issue with material or financial rewards. Thus, especially since the *Citizens United* decision, financial influence is an overwhelming factor in US elections. Candidate selection is made worse by the excessive length of campaigns and/or by choosing candidates through a non-representative proxy process.

Nonprofit advocacy groups promote positions that are mostly in the public's interests and are supported by individual donors. Citizens concerned about a particular issue using information and voting pressure to gain the attention of politicians build advocacy groups. For example, the many CC groups emphasize different aspects of the CC issue: policy, economics, technical solutions, research, or the security and wellbeing of our country and planet. When talking to members of the public about CC issues, it is important for advocates to be empathetic, especially with those far behind them on the learning curve, where all of us started out. Spoken science can be intimidating and should not be explained in a belittling manner but in the context of caring for the common good.

It is important also that the CC advocates be diverse in a manner representative of the general public, e.g. in occupation, in expertise, and in cultural background and orientation. Such diversity provides a broad range of social experience with public engagement that can help build a more integrated approach. For example, in a local newspaper or news journal, a group could publish a linked sequence of articles that would build a broader perspective on the need and urgency of CC action. A similar approach can be used in responding to comments of "concerned, cautious, or doubtful" members of the local population and might be more effective than a series of disconnected articles. AmericaSpeaks[68] was a very successful non-profit that combined a number of deliberative methods to educate, discuss, and create consensus on important issues to provide policy makers (participating) with a solid basis to make legislative solutions. These methods are important considerations for presenting constructive information, avoiding mixed or conflicting messages, and achieving a greater level of consensus for urgently needed action. (Note, Chap. 2 further discusses the issue of public awareness).

Chapter 1, Section B & C Endnotes

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[40] **Residence time** is a term used to estimate the average length of time of a substance remains in a reservoir or system. For example, the length of time CO_2 molecule emitted from a vehicle remains in the atmosphere. Its residence time depends on how and where it enters the atmosphere, and how it reacts chemically in the atmosphere, leaves the atmosphere, or how quickly it is absorbed by land or water. For this reason, its average time can only be estimated. See https://en.wikipedia.org/wiki/Greenhouse_gas#Atmospheric_lifetime.

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[42] **Interglacial Optimum period –** The period when the northern hemisphere gets maximum exposure to sunlight within the Milankovic Cycles. https://en.wikipedia.org/wiki/Interglacial#

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[46] **Precautionary Principle.** Listed among the 27 Principles to guide sustainable development of the Rio Declaration. h**ttps://en.wikipedia.org/wiki/Rio_Declaration_on_Environment_and_Development**

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[50] **Ibid. #25**

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[52] **Earth Systems Models,** http://www.gfdl.noaa.gov/earth-system-model

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[55] **Citizens' Climate Lobby, www.citizensclimatelobby.org**

[56] **Industrial Ecology 2nd Edition. 2010.T. E. Graedel, B. R. Allenby.**

[57] **Ibid. # 30**

[58] **https://sustainabledevelopment.un.org/post2015/transformingourworld**

[59] **120815 outcome-document-of-Summit-for-adoption-of-the-post-2015-development-agenda.pdf.**

[60] **US leadership for Climate Change and other GC** is restricted by the current Congress, which would undoubtedly continue if the opposition party remains after 2016 elections.

[61] **The 350.org movement.** http://350.org

[62] **Climate Reality Project.** https://www.climaterealityproject.org

[63] **Fossil Free,** *Divesting from Fossil Fuels*. **gofossilfree.org**

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[68] **AmericanSpeaks,** was a non-profit organization whose mission was to "engage citizens in the public decisions that impact their lives."