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Integrated 1000-year planning

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Abstract

This paper develops the concept of integrated 1000-year planning. The products of 1000-year planning, referred to as 1000-year plans, are intended to deal with issues on a global scale and address the survival of humanity and the protection of the earth's environment. One thousand years is an appropriate global planning horizon because it is long enough to unmask big picture problems that appear to be invisible to today's societies. Furthermore, this time horizon encourages the perspective that over the long-term, many problems that seem unsolvable today, and therefore receive little attention and few resources, can indeed be overcome. Topics of 1000-year plans are numerous and include: energy, land use, carbon management, oceans, biodiversity, nuclear and hazardous waste, water, human settlements, near-earth objects, and space exploration. The argument is made that responsibilities for action by current generations to benefit future generations be based on risk assessments and risk thresholds. In the near-term, 1000-year planning must be driven by an international grassroots coalition of scientists, policy analysts, environmentalists, planners, and concerned citizens.

1. Introduction

My concern here is to develop the concept of integrated 1000-year planning. The primary motivation behind 1000-year planning is the reduction of threats to the long-term survival to humanity and other life on earth, with improving the quality of life for life on earth over the long-term as a secondary motivation. The purpose of 1000-year planning is to develop 1000-year plans. Like any plans, 1000-year plans should be composed of sets of intended future actions designed to achieve well specified goals. Today, everyone and every organization plan to some degree. Individuals plan daily activities, as well as activities for tomorrow and next week. Organizations

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develop hiring plans, capital investment plans, and marketing plans. Not to be ignored, governments also develop plans related to education, land use, roads, and many other responsibilities. Differences between every day planning and 1000-year planning simply involve time horizons and the scope of intended actions. The latter plans ought to encompass all of humanity and the earth's environment and be composed of elements that focus on global topics such as carbon management, biodiversity, energy, and space colonization.

Plans that address the survival of humanity *writ large* do not exist despite the plethora of threats to our well being. Currently, global plans with narrow foci do exist, as set out in international treaties and protocols. Examples of global plans include the Montreal Protocol on Substances That Deplete the Ozone Layer, the Kyoto Protocol to the United Nations Framework Convention on Climate Change, the Treaty on the Non-proliferation of Nuclear Weapons, and the 1982 United Nations Convention on Law of the Sea. Unfortunately, these efforts suffer from several deficiencies. One problem is that these kinds of plans are not integrated with each other. Each one has its own narrow focus. Opportunities for synergies to accrue from integrated planning (i.e., humanity would benefit more from a whole set of integrated plans than from the sum of the individual plans) are lost because each plan is developed in isolation from the others.

Another problem is that the plans have relatively short time frames despite the fact that global problems require a very long-term perspective. The short time horizon of the Kyoto Protocol, which focuses on current greenhouse gas emissions by developed countries within a two-decade time frame at the exclusion of longer-term issues posed by emissions from the developing countries such as China, is a case in point. A third problem is that global plans, or even important regional plans, do not exist for many important topics, such as energy, water, and land use. In combination, these problems with global plans threaten our ability to overcome the many threats to humanity's well being. In essence, we are attempting to maintain Spaceship Earth by only paying attention to a subset of subsystems, by only trying to fix already broken subsystems, and by considering each subsystem in isolation from the other subsystems. Without holistic, integrated, and future-oriented proactive actions, the health of Spaceship Earth will only be protected and nurtured over the long-term by chance.

The next section of this paper addresses the question: Why 1000 years? The third section presents key elements of 1000-year plans and discusses their integration. The fourth section tackles the issue of risk: What obligations do current generations have to reduce risks to future generations? The fifth section discusses who should do 1000-year planning, at least in the near-term. The paper concludes with an assessment of the prospects for 1000-year planning.

2. Why 1000 years?

Why tackle 1000 years and not shorter, more imaginable and manageable time horizons? Why worry about the long-term when there is so much suffering in the

world right now? The most direct answer is that the world needs to focus both on improving the plight of the world's poor in the short-term and protecting everyone's well-being over the long-term. Focusing only on the short-term is like worrying only about how to arrange the chairs on the deck of the ill-fated Titanic. All the good work at improving the arrangement of the chairs was lost because the longer-term issue (the survival of the ship) was completely mis-handled, in part through misplaced overconfidence in the ability of the ship to withstand adversity. In the same way, short-term activities to improve people's lives, whose value should not be diminished in any way, could be completely washed away (literally in the case of global warming) by problems orders of magnitude more serious and intractable if the future is not also dealt with.

Short time horizons constrain if not completely mask the recognition of big picture issues and threats. For example, over the next ten years, oil supplies may be manageable; over 1000 years, oil supplies and those of natural gas will probably be completely exhausted, thereby threatening the world's economic and political stability if a plan is not in place to develop substitutes for these fossil fuels [1]. Over the next 50 years, rising sea levels may not be devastating, but within 1000 years, large swaths of countries like Bangladesh will most certainly disappear.[1] Humanity must be prepared to deal with climate change induced human tragedies, as the window to prevent global warming has now closed. Even though only a fraction of the earth's tropical rainforests disappear each year, add those small changes up over 1000 years and the forests are gone forever. Thus, by playing out important trends past normal policy horizons, the bigger picture contains some very disturbing and dangerous potential states-of-the-world.

The longer time horizon is also needed to facilitate a qualitative change in mindset from the short-term to the long-term. In a seeming paradox, with a longer time perspective, some actions will come to be seen as more urgent, such as actions needed to protect tropical rainforests and manage energy supplies. Longer-term perspectives indict the inherent selfishness of many of today's economic and social policies, based as they are on purportedly rational theories but in reality on irrational, self-fulfilling and dogmatic belief systems that temporally discount moral and ethical obligations to future generations. A 1000-year perspective is long enough to drive home the point that humans will most likely be living on this planet, with few or no other true alternatives, for many thousands if not millions of years into the future. The daily closing state of the Dow Jones Industrial Average as a matter of importance ought to pale in comparison with the goal of keeping the planet liveable into the very distant future. This realization should lead to another, that 1000-year planning ought to be a permanent responsibility of humanity. In other words, even though 1000-year plans will most certainly need to be systematically evaluated and revised, maybe as often as every five years, humanity must accept permanent responsibilities

[1] For more information on climate change and sea level rise, visit the United Nations Environmental Program on the potential impacts of climate change at http://www.crida.no/climate/vital/33.htm.

for wise use of energy, land, ocean, and among many important resources that sustain life on earth.

A longer-time horizon is also needed to allow humanity to achieve the next to impossible. Many of today's habitual naysayers preach inaction because they do not believe success is achievable, *in the near-term*. For example, we do not now have the technologies to defend the planet from collision with space-based objects and will not in the short-term, so the thinking is why spend much if any money on this endeavor. Of course, with that myopic view, conditions might never arise that would support the development of such technology. With a 1000-year perspective, the odds appreciably increase that such technology could be developed and deployed, so why not start today! The relatively small amounts of global funding allocated to fusion energy, space colonization, and carbon management are to some degree the result of myopic naysaying and would probably be increased if perspectives were lengthened and broadened. The longer time frame should foster the wisdom and allow the patience needed to envision the implementation of comprehensive, challenging and integrated global plans.

Finally, it should be noted that the notion of 1000-year planning, or at least the recognition of the importance of thinking so long-term, is taking root, albeit only at its beginning stages. For example, the Foundation for the Future, located in Bellevue, Washington, USA, has adopted 1000-years as its period of analysis and assessment.[2] The Long Now Foundation, located in San Francisco, California, USA, is, among other projects, developing a 10,000 year clock.[3] It is also interesting to note that there are numerous human institutions that have existed for comparatively long periods of time, which suggests that 1000-year planning is already within the institutional capabilities of humans. For example, the current Sangha community of Buddist monks was founded by Siddhartha Guatama around 500 BCE [2]. Several monastic orders are many hundreds of years old; for example, the Dominican monastic Order of Friars Preachers was founded in 1216 and Francis of Assisi founded the Franciscan monastic order in 1210. Many universities have similar ages. The University of Paris was founded about 1170 and several colleges at Oxford were founded long ago (e.g., University College in 1249 and Balliol College in 1263). Lastly, maritime law was first institutionalized about 2000 years ago, through the efforts of Rhodes, as testified to by surviving written comments from Roman emperors.

3. Elements of 1000 year plans

An integrated global 1000-year plan should have several key elements, which are addressed in this section.

[2] For information about the Foundation for the Future, visit http://www.futurefoundation.org.

[3] For information about the Long Now Foundation, visit http://www.longnow.org.

3.1. Energy

Energy is the Dr Jekyl and Mr Hyde of human civilization. On one hand, the prolific use of energy is the foundation of today's advanced economies. On the other hand, the burning of massive amounts of fossil fuels has increased the amount of greenhouse gases (GHGs) retained in the atmosphere so much that the earth now faces the prospect of a series of catastrophes caused by global warming [3]. To complete the picture, several reputable energy analysts now predict that within a decade or two at most the world's oil production will reach its historical peak and then will decline for the rest of recorded human history [1]. Within 1000 years, it can be argued that natural gas supplies will also be severely if not completely depleted. Thus, on the horizon are threats to the global economy and the earth's biodiversity related to energy use. A worldwide plan is needed now to move away from non-renewable fossil fuels so as to ensure adequate energy supplies for the next 1000 years. The plan must emphasize energy-efficiency and use of renewable resources. To the degree that the plan calls for the use of biomass, the implications for global land use must be considered. To the degree that the plan relies on nuclear power, long-term solutions to the disposal and administration of nuclear wastes must be implemented.

3.2. Land use

Presently in most places in the world, there are no land use controls, much less rudimentary land use plans. Individuals seek to maximize their own welfare when they convert precious ecological resources into farmland or human developments, generally heedless of the larger and longer-term implications of their decisions on current and future aggregate social welfare. Millions of individual myopic and short-term land use decisions are constantly chipping away at the integrity of ecosystems and the productivity of other lands. In combination, the existence of every land-based ecosystem and productivity of every hectare of land is threatened within a 1000-year time horizon. The admittedly radical and controversial solution is that every square meter of every land mass on earth needs to be encompassed within a global land use plan. There is no other way to ensure the survival of the earth's land-based biodiversity heritage while also ensuring that enough lands for agriculture, forests and grazing are available for current and future generations. As mentioned above, the land use plan must encompass plans for biomass energy. The land use plan must also be consistent with the plan for human settlements discussed below.

3.3. Carbon management

The most recent report from the Intergovernmental Panel on Climate Change (IPCC) forecasts that the mean global temperature will increase between 1.4 and 5.8 °C over the next 100 years [3]. Among many potential significant impacts, global climate change may exacerbate already extreme worldwide water shortages [4], adversely impact agricultural production [5], lead to increased flooding and sea-level

rise [6], and increase populations at risk of malaria [7]. Climate change also promotes the invasion of pests, pathogens, and exotic species. In sum, millions are at risk due global climate change [8]. Any or all of these impacts may also result in substantial economic disruptions, political instability and even protracted worldwide violence.

At this point, it is not enough to reduce the emissions of GHGs through more rational energy policies. The message I take from the IPCC report is that the build-up of GHGs in the atmosphere is already too great to stave off global warming. One solution is to implement a global carbon management plan based on carbon sequestering, which is the drawing of carbon out of the atmosphere and storing it somewhere so it would not leak back into the atmosphere.[4] Over a 1000-year period, it is also possible that global cooling could become a threat, so that carbon management could also take the form of de-sequestering carbon locked in the earth. To the degree that land-based and ocean-based sequestering approaches are used, these plans should be integrated with the land and ocean use plans.

3.4. Oceans

Similar to land use, oceans are impacted by tens of thousands of individual decisions every day. These decisions are leading to the depletion of fishing stocks around the world and the contamination of coastal areas with urban and rural waste products. Additionally, the oceans are being impacted by global climate change, primarily through sea level rise; rising ocean temperatures is also bleaching and killing a high percentage of the world's coral reefs.[5] Sea level rise threatens the world's estuaries, which are important nurseries of biodiversity and food supplies. Over a 1000-year time horizon without a global management effort, ocean resources and biodiversity could be completely devastated. Urgent attention is needed to mitigate the impacts of global warming on ocean resources, allowing that such mitigation efforts may span centuries.

3.5. Biodiversity

Protection of biodiversity is a theme that runs through many of the elements of 1000-year plans, such as the land use and ocean management components. The energy and carbon management elements are also motivated by the need to protect biodiversity. However, it is still important to include a specific element in 1000-year plans that addresses biodiversity. This element needs to take a very long-term view of biodiversity and the functioning and processes of the world's ecosystems. In fact, this view needs to be evolutionary. In a healthy network of global ecosystems, evolution will occur naturally. Constraints on natural evolutionary processes may irrevocably damage biodiversity over the long-term. Humans' over-management and frag-

[4] For more information on carbon sequestration, visit the US Department of Energy site on this topic at http://www.fe.doe.gov/coal_power/sequestration/index.shmtl.

[5] For more information on threats to coral reefs, visit the World Resources Institute site on this topic at http://www.wri.org/trends/coral.html.

mentation of ecosystems for their own uses act as such constraints, thereby potentially reducing the scope and scale of natural evolution. Thus, over the long-term, 1000-year plans not only need to protect hot spots of biodiversity,[6] but must also work to unfragment ecosystems and loosen their 'management'. Particularly challenging yet important to accomplish is the task of integrating human settlements into the 'natural' environment, an activity I refer to as re-environmentalization.

3.6. Nuclear and hazardous waste

Particularly noxious by-products of our technological civilization are nuclear and hazardous wastes. These wastes can mortally harm humans and other species and therefore merit special attention for disposal. What sets these wastes apart from other types of dangerous wastes is their longevity. For example, the half-life of plutonium is over 24,000 years. Some hazardous wastes, such as lead and asbestos, do not decay and therefore represent permanent threats [9]. One response to the long-term disposal of radioactive waste has been to design nuclear waste repositories in such ways that their contents could be communicated to unknown future generations at least 10,000 years into the future [10]. This approach implicitly assumes that some sort of catastrophe will result in the de-population of areas around the repositories, leaving no one to remember their contents. Since a strong presumption of 1000-year planning is that such catastrophes would be prevented, a response more in-tune with 1000-year planning would be to focus on building resilient institutions capable of being reliable stewards of these wastes for thousands of years in the face of almost certain political and economic instabilities [11]. The working assumption is that people will be around these sites into the indefinite future and therefore a small group of people could have responsibilities for the sites. It also should be assumed that these types of wastes will continue to be produced into the indefinite future, as even the much hoped for fusion energy technology will generate some radioactive wastes.

3.7. Water

Over a billion people currently suffer from a shortage of clean water.[7] The recent environmental summit in Johannesburg, South Africa highlighted this global problem. All over the world, water supplies do not match demand. Even in developed countries such as the United States, rivers are being over-tapped and aquifers are being depleted faster than they are being replenished. Although water supplies are generally considered local issues, water needs to be an element of 1000-year plans. This is because other elements of the plan have strong relationships to water, including the energy, land use, biodiversity, ocean management, and human settlement.

[6] For more information on biodiversity hot spots, visit the Conservation International site on this topic at http://www.conservation.org/xp/CIWEB/strategies/hotspots/hotspots.xml.

[7] For more information on the global water situation, visit the United Nations Environmental Program on this topic at http://www.unep.org/geo2000/pressrel/water.htm.

Another reason is that the 1000-year perspective brings into sharp focus the potential for the complete depletion of the world's underground aquifers within the planning horizon. Lastly, the absolute need for water and expenses for providing water to arid and over-developed places (e.g., by towing icebergs from the Antarctic for fresh water) may contribute to global decisions about the relocation of millions of the world's citizens.

3.8. Human settlements

This element of 1000-year planning deals with human settlements on a global scale. Certainly, the planning of human settlements has a long history, as can be seen in the intelligent designs of ancient cities in the Middle East up to today's modern urban and land use planning. However, these types of planning activities are too limited, too focused on managing geographical spaces to provide for the needs of current inhabitants. Large parts of Bangladesh will be inundated from rising sea levels, tens of millions cannot sustain even a meager existence in sub-Saharan Africa, and the prospects for agricultural lands to continue to support the hundreds of millions of people in India and China without a major collapse over the next 1000 years are dim. There are too many people living in proximity to the world's rain-forests to guarantee these important natural amenities will not be destroyed for human developments and agricultural land. The combined ravages of sea level rise, desert-ification, depletion of fresh water supplies, and exhaustion of agricultural lands, plus the need to protect ecosystems, means that from a global perspective, massive num-bers of humans probably should live in other parts of world. The human settlement plan would address how many people from different places on earth should move and to where they should move. The plan also needs to address adaptation and mitigation strategies, especially in response to global climate change, that could minimize the need to relocate people around the world. This element of the plan must be tightly coordinated with the land use, water, and energy elements of the overall plan.

Population forecasts need to be included in the human settlement element of 1000-year plans. This is because human population is one of the major drivers behind most of the issues considered by 1000-year planning, from energy management to land use decisions to protection of the oceans and biodiversity. An important question for 1000-year planning is whether the plans ought to include an element focused on population management and control, as China has implemented through its one-child policy. Should worldwide population targets be developed over the 1000-year time horizon? Should the world's societies decide upon and plan to achieve an optimum human population for planet earth? Maybe, even though such decisions are fraught with ethical difficulties. However, strict population control, as practiced in China, should not be an element of 1000-year planning. I believe that human population decisions transcend even the global perspectives of 1000-year planning. Thus, 1000-year planning, while being exceedingly proactive, is still reactive in a sense to people's values and preferences regarding children and affluence. That said, it is vitally important that through the process of 1000-year planning, the tradeoffs and risks associated with unsustainable population growth and affluence, regardless of

heroic 1000-year planning efforts, should be made as explicit as possible to every human being in the world. Using the latest in modeling and visualization techniques, this information could be communicated via a global 1000-year planning television channel, frequent publications, and interactive websites. In this way, 1000-year planning can practice advocacy as related to population control while still maintaining its main responsibilities for reacting to human values and preferences.

3.9. Near-earth objects

Another task to include in 1000-year plans is defending earth from threats posed by near-earth objects [12–15]. If we were to leave nothing to chance in this area, then a massive effort would be needed to identify all potentially dangerous NEOs, track them over time, and deploy appropriate space-based technologies to change the trajectory of those few that pose danger to the earth and perhaps even the moon. Because many potential NEOs cannot be identified from earth or maybe even from telescopes orbiting earth, several space-based telescopes would need to be built and deployed far away from the earth to serve as early warning systems. Because some hard to identify NEOs could threaten the earth with little forewarning—some long-period comets, those that revolve around the sun with a period of more than 200 years (some millions of years), may only be spotted 250–500 days before impact—it may also be wise to base spacecraft far away from the earth that could intercept such objects within a comfortable time frame and change their trajectories. The situation today is that NEO detection receives very little funding and most telescopes cannot detect objects smaller than one kilometer in size.

3.10. Space exploration

This activity, compared to other elements of 1000-year plans, is more commonly thought of as a long-term endeavor. Of course, today, humans can only dream of colonizing the solar system and other planets in our galaxy. Yet, there also seems to be a certain pre-destination to accomplishing this task. So, let's set out a 1000-year space exploration plan to replace the short-term, nationally fragmented plans now in place. The plan should be robust and challenging yet also have practical aspects. For example, Robert Zubrin discusses the likely need to mine asteroids for energy sources and precious metals [16]. The plan should also tap into humankind's natural curiosity and needs for achievement. Maybe through space exploration, energies now focused on international competition and war can be put to uses that are more constructive.

3.11. Integration

Integrated 1000-year planning focuses on the whole of Spaceship earth and simultaneously on all important systems and subsystems. Thus, all of the elements listed above must be integrated with each other. For example, the energy plan should be inter-related with the carbon management plan, which should be inter-related with

the land use plan. Where people live should be determined not as much by historical accident as by the carrying capacities of ecosystems and the availability of fresh water and agricultural lands. It is hard to prioritize elements of 1000-year plans because they are so integrated. It is also hard to label some issues as near-term and others as long-term if they all require some attention by current generations. These qualifications notwithstanding, energy would seem to head a list of prioritized topics because of its pervasive impact on every aspect of the environment and human life and most other elements of 1000-year plans.

Opportunities for crosscutting research and development (R&D) need to be identified and pursued. For instance, clean energy technologies can help meet energy demand, facilitate carbon management, and may even have a use in space. Ever more advanced computing technologies are needed to support ever increasingly sophisticated science and technical engineering challenges. Progress in the area of nanotechnology promises to have impacts on energy technologies, water purification, and space craft development and many others, including bioengineering, biometrics, automation, cybernetics, etc. that could have untold cause-and-effect relationships with many systems. Social science and evaluation research are needed to help assess not only the process and progress of 1000-year planning but also to assess humans' abilities in organizing themselves and in making decisions that have long-term impacts. Although goal directed R&D has been quite successful in recent years (witness advances in space exploration, computing, biotechnology), a high degree of flexibility must be built into the R&D process to allow for innovation and serendipitous discovery. Advances in technology should be considered in 1000-year plans. However, following the precautionary principle, plans should not be based on technologies that do not exist or are uncertain to come into existence within the time frame under consideration.

More focused plans, spatially and temporally, should continue to be developed to protect human health, spur sustainable development, maintain important local infrastructure, and educate the citizens of the world. People will continue to plant crops, build homes, produce electricity, go to school, and drive their automobiles. Local plans related to agriculture, economic development, energy, education and transportation will still need to be developed but ought to be done in concert with the relevant elements of 1000-year plans and should also be integrated as much as possible.

Lastly, upon integrating the elements of the a 1000-year plan and assessing long-term risks to humanity and the environment (risk is discussed more in the next section), it may become apparent that bad times are likely if not unavoidable. Certainly, one view of our current situation does not bode well for future generations. Our thirst for non-renewable energy resources, impending climate change, depletion of water supplies and soil quality, just to begin the familiar list of problems, could render it impossible for future generations to enjoy a similar quality of life. It may even be necessary for 1000-year planners to plan for new dark ages as well as for even better times.

4. Responsibilities for action

As stated in the introduction, the foundation of planning is the intention of future action. With respect to 1000-year planning, intentions represent international collaborations to accomplish tasks that may be initiated tomorrow or many years from now and span a few to several hundred years. The question addressed in this section is this: What sacrifices should be made today to reduce risks to future generations?

The argument can be made that one way to answer this question is through risk assessment. This framework for analysis entails identifying potential risks, describing pathways or causal chains that could result in the occurrence of unwanted events, and estimating the probabilities that the unwanted events will occur given current knowledge and policies. In the early days of risk assessment, focus was on identifying risks associated with the malfunction of nuclear power plants. Now, at the beginning of the 21st century, risk assessment is a widely used tool in industry and government. In the United States, risk assessment is widely used in the development of environmental regulations to protect human health. The goal is to adopt cost-effective regulations that reduce the involuntary mortality risks to individuals to acceptable levels from environmental precursors, such as tropospheric ozone, particulate matter and fecal coliform.

A key question in risk assessment is: what is an acceptable risk? In the United States, human health risk assessment seems to have moved to a de facto standard of one-in-a-million. In other words, individuals ought not be subjected over their lifetime to a risk of death greater than one-in-a-million from any specific, involuntary, environmentally-based risk. For example, the safe level of arsenic in drinking water is the level where there is less than or equal to a one-in-a-million chance that an individual will die of cancer, heart disease or some other disease attributable to drinking arsenic contaminated water. Subjecting individuals to higher levels of risk is considered to be unethical and enough money should be spent to reduce risks when necessary. This is typically the case in the United States, although not the rule.

Using a US-based risk threshold for internationally-oriented 1000-year planning may be seen as objectionable to many from other countries. However, because US emission of GHGs is the major cause of global warming and because one-in-a-million is a fairly stringent risk threshold, there is some value in using the US' own standards in the attempt to breach the consciousness of the American public and politicians about the seriousness of the long-term problems.

This approach to risk assessment, setting a risk threshold and spending whatever it takes to reduce risks below the threshold, has some merits for deciding responsibilities for action with respect to 1000-year planning. However, 1000-year planning is a substantially different context than environmental regulation. One difference relates to the event set as it is probably not useful to define 1000-year planning risks in terms of individual mortality risks because 1000-year risks are broader and more diffuse. Also, the risks considered by 1000-year planning may span generations; thus, the event set associated with 1000-year planning risks needs some additional attention. Lastly, the one-in-a-million rule-of-thumb itself needs considerable refinement. If the United States manages individual environmentally-based health risks to this

level, to what level should the world manage 1000-year risks that may lead to catastrophic economic consequences, massive species die-off, and even the possible extinction of the human race?

The literature on obligations to future generations is reviewed to help develop the event set. The literature addresses obligations from three viewpoints: fairness, maintaining options, and ensuring quality of life. The fairness obligation concerns not imposing risks on future generations that present generations would also not accept. For example, Douglass MacLean's neutrality criterion states that "levels of risk to which future generations will be subjected will be no greater than those of present persons" [17]. Risks can include risks of premature death from environmental or other preventable catastrophes [18]. Fairness also has an element of consent. According to Kristin Schrader-Frechette, "Until or unless a risk imposition receives the consent of those who are its potential victims, it cannot be justified" [19]. The fairness obligation indicates the risk threshold for 1000-year planning decisions ought not to exceed one-in-a-million, at the very least.

The maintaining options obligation entails gifting to our posterity future worlds that are as free of man-made constraints as possible. In other words, there is a need to prevent environmental and other catastrophes "that would restrict the future of the human race by cutting off certain possible futures" [20]. By cutting off many futures, the ability of future societies to grow and mature is reduced [21] as is the freedom for people to "reason about means and ends and evaluate preferences, to match desires and beliefs and then act" [22]. Edith Weiss Brown's Principle of Conservation of Options holds that: "Each generation should conserve the diversity of the natural and cultural resource base so that it does not unduly restrict options available to future generations…" [23]. Wendell Bell states that "there is a prima facie obligation of present generations to ensure that important business is not left unfinished" [24]. That said, the option to finish unfinished business must be keep alive. This obligation indicates that situations where future generations are saddled with extreme economic burdens and precious few life choices beyond survival ought to be avoided. It also suggests that the risk of extinction ought to be kept extraordinarily low.

The quality of life obligation refers to ensuring that future generations enjoy all the most important aspects of life. Allen Tough presents these quality of life obligations to future generations: peace and security, a healthy environment, a small risk of preventable catastrophe, stable governance, conservation of knowledge, a good life for children, and opportunities for living [25]. Wendell Bell also believes that humility and the cause of humanity create obligations to future generations. In his own words: "Humble ignorance ought to lead present generations to act with prudence toward the well-being of future generations" [24]. This last point also argues that risks should be kept low and actions should be proactive so as to minimize the impact of 'surprises' over the long-term, such as could be associated with climate change [26].

Distilled from these ideas are the following: that a risk-based approach to 1000-year planning ought to manage risks in the aggregate at the very least at the one-in-a-million threshold, following MacLean; and that the event set ought to address

more than simply mortality risk, to include a range of issues, starting with quality of life issues and ending with the ultimate risk, extinction of the human race. With these thoughts in mind, proposed are the following three categories of risks to be the foci of 1000-year planning:

- Category I. Substantial regional economic, political, and/or biological impacts.
- Category II. Severe global economic, political, and/or biological impacts.
- Category III. Extinction of humans.

Category I addresses major regional concerns and includes morbidity as well as mortality risks. Category I brings international equity concerns into 1000-year planning as no region ought to be allowed to suffer substantial harm while other regions look on. Category II encompasses global calamities that are likely to cause many deaths. In this aspect, Category II is most analogous to current risk-based environmental regulation in the United States. Category III is, as mentioned above, the ultimate risk, which, of course, is beyond the regulatory purview of any one nation but is appropriate in a global context. A fair question is whether this category is needed. Could the aggregated risk from a broad set of threats actually lead to the extinction of *Homo Sapiens*? Certainly, the answer is yes, plausible scenarios can be developed where this happens. For example, extreme and rapid global warming could result in such a catastrophic die-off of species that the earth could become inhabitable for humans. While the probability of this scenario occurring may be very small, the probability of extinction may already exceed an ethical threshold for that risk.

Responsible action is required if the probability of any category of risks exceeds pre-determined levels at any point during the 1000-year planning horizon. As expected, pre-determined risk levels and immediacy of action are less stringent for Category I risks than for the Category III risks. Fig. 1 helps to illustrate this point. In panel A, the risk of a Category I event exceeds the pre-determined level (suggested to be one in a million or 10^{-6}) for a short period of time and then subsides without any changes in human behavior. This is assumed to be an acceptable situation because the risk level does not vastly exceed one-in-a-million and only does so for a short period of time. Panel B depicts a situation where the probability of a Category I event exceeds one-in-a-million and shows no signs of subsiding. In this case, some action needs to be taken to reduce the risks to less than one-in-a-million sometime within the action window, which straddles the point in time when the risk exceeded one-in-a-million.

Panel C relates to a more severe risk, a Category II risk. In this case, it is not acceptable for the risk to exceed the pre-determined level at any point in time, regardless of whether or not the risk appears to subside over time. Additionally, it can be strongly argued that the pre-determined risk threshold should be more stringent than one-in-a-million, suggested here to be one-in-one-hundred-million (or 10^{-8}). In other words, since the consequences are orders of magnitude worse than in the Category I case, humanity should tolerate orders of magnitude less risk that the event will transpire. This logic is taken even farther in the Category III case. The risk threshold

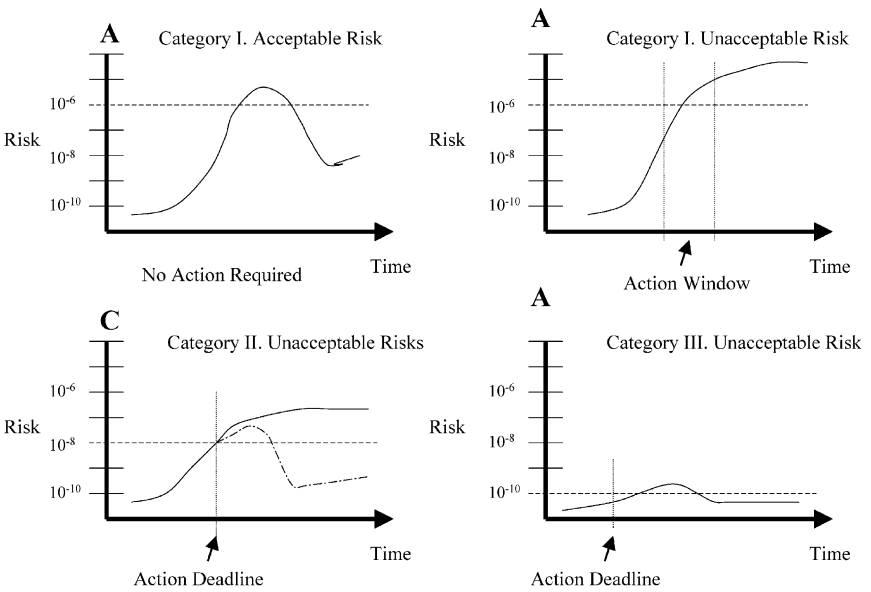

Fig 1. Categories of risk and action profiles.

is set at one-in-ten-billion (or 10^{-10}) and the risk must be reduced well before that risk level is hit. This exceedingly small risk threshold makes sense when compared to the expected remaining life-time of the earth, which is in the neighborhood of four billion years, at which time the earth will be incinerated by an expanding and dying sun.

These categories of risks are not mutually exclusive. As indicated by Fig. 2, Cate-

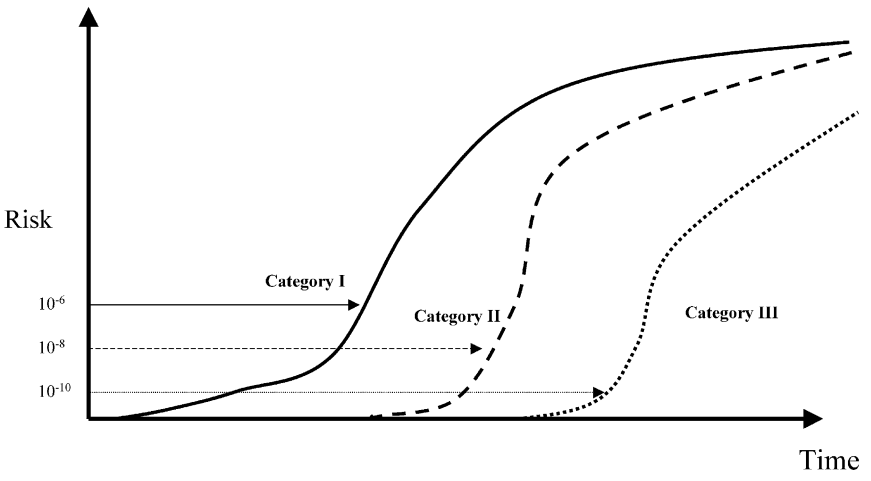

Fig. 2. Relationships among risk categories.

gory II could subsume Category I and Category III could subsume Categories I and II. In most cases, if Category I risks are acted on promptly and effectively, the world will never experience the other categories of risk. However, depletion of the stratospheric ozone layer, for example, is a risk that is global and not regional per se, so the relationships indicated in Fig. 2 are merely suggestive. Of course, since none of detailed quantitative analysis has yet to be performed to establish what risks the world currently faces, it is possible that the world currently exceeds Category I and II and maybe even Category III risk thresholds. It should also be pointed out that the risk curves do not have to be smooth and continuous. If scientists forecast major discontinuities in the climate, for example, where risk levels could rise dramatically in only a few years time, these discontinuous changes can be accommodated by step-functions in the risk curves.

A risk-based foundation for responsible action with respect to 1000-year planning is promising but is far from being easy to implement in practice. The problems addressed by 1000-year planning are considerably more complex than those adequately dealt with by current risk assessment techniques. Each of the definitions for the three categories of risks listed above need to be fleshed out considerably. Ways to estimate probabilities need to be developed. This is not a trivial exercise since there are no data about the future upon which to base the calculation of probabilities. How to aggregate risks due to the various problems posing risks to humanity is also an open question. It should be noted that these types of difficulties have hindered the use of probabilities in the assessments of future climate change conducted by the Intergovernmental Panel on Climate Change [27,28].

5. Who should develop 1000 year plans

Who should develop integrated 1000-year plans? Grassroots groups of scientists, planners, environmentalists, and other concerned citizens, along with dedicated non-governmental organizations and sincere private sector organizations. Participants need to have global perspectives and future-orientations. Unfortunately, most nation states do not meet these criteria. The hyper-self-interests, myopia, and power politics of nation states are not currently conducive to 1000-year planning. It is very hard to imagine nation states working collaboratively to develop global land and energy use plans and especially hard to imagine them discussing the ‘rational’ distribution of humans across the planet that might be substantially different from today’s distribution with its regional ghettos in virtually uninhabitable parts of Africa and Asia. At least in the beginning, 1000-year planners will have to work outside the normal channels of government and work at the grassroots level the world over to publicize their results and mobilize long-term change.

One nominally grass-roots effort to influence the future-orientation of humanity’s thinking has been the Intergovernmental Panel on Climate Change. The framework for the IPCC was established by the World Meteorological Organization and the United Nations Environmental Program (UNEP) in 1988 to assess current knowledge about climate change and use the current knowledge to forecast magnitudes and

impacts of climate change. It should be noted that hundreds of scientists from around the world contribute their time gratis to this endeavor, which gives the IPCC its grassroots characteristics. Also supporting its grassroots persona are the IPCC reports, which have become more influential after each assessment process despite growing hostility to the IPCC from conservative governments (e.g., the US government) and from oil producing nations. It could be argued that even if the UNEP dropped its financial support for some limited aspects of the IPCC, the IPCC would continue as an organized, international grassroots initiative to influence world climate policies. Thus, a 1000-year planning effort could do worse than to pattern itself on the IPCC model.

The grassroots effort should not only focus on the development of 1000-year plans but also on slowly building the institutional capacity to implement the plans. Institution building will help to improve relationships among people around the world. The benefits of institution building should also percolate up into national governments, thereby improving the chances that they will be able to cooperate in this venture at some point in the future. After all, eventually decisions will need to be made about who will pay for what, accomplish what goals, and whether 1000-year plans should be codified through international legal processes.

6. Prospects and conclusions

The near-term prospects for comprehensive, integrated 1000-year planning are not great. For one reason, 1000-year planning is an enormous undertaking as it encompasses every area of the globe and must deal with extraordinarily challenging data collection, modeling, and other intellectual challenges. For another reason, the disappointing results of the most recent global environmental summit in Johannesburg, South Africa, clearly indicates that many nation states are not capable of putting the public interest and the interests of future generations above their own short-term political interests.

On the other hand, the elements needed for an international grassroots 1000-year planning initiative either exist or will soon come into existence. Already in existence are numerous active and technically competent international environmental non-governmental organizations. These groups collectively are working to facilitate land use and ocean planning, and wean the world off non-renewable fossil fuels. While the private sector has been largely vilified by environmentalists, there are indications that some companies are beginning to embrace sustainability and should also be included in the initiative. Global land use and satellite databases are becoming available, as are the supercomputing and other computer resources to process the data. Research centers around the world are homes to dedicated scientists who are contributing to ‘saving the world’. The global span of the Internet now makes it comparatively easy for these people to communicate with each other. Still to come is an organizational framework that can coordinate forecasts and predictions. The framework would also need to be robust enough to manage the extremely difficult issues that are sure to arise in the development of 1000-year plans, such as to what

extent the world should rely on nuclear power and if, when, and where tens of millions of people would need to relocate around the globe.

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