Opinion

Prospective Approaches for Ecosystem Sustainability Including Climate Mitigation

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ABSTRACT: A summary, based upon foresight, futures, ideation and frontier technology studies of prospective approaches to foster ecosystem sustainability including climate mitigation at the technology and societal levels which are at scale and profitable. Approaches summarized include halophytes/salt plants grown on deserts/wastelands using saline/seawater, to address land, water, food, energy and climate, frontier energetics, nascent climate mitigation concepts, cellular agriculture, materials optimization, the virtual age, efficiency and redesigning the ecosystem for the Anthropocene. Solution/mitigation approaches are targeted at deforestation, desertification, pollution writ large (land, sea, air, space), and extensive urbanization along with soil salination, ocean acidification, mining, and water scarcity.

Keywords: Climate mitigation; Green energy; Agriculture alternatives; Ecosystem optimization; Water solutions; Virtual age; Do-It-Yourself; Profits

1. Introduction

The ecosystem aka biosphere provides life essentials for humans including water, air, food, soil, plants and minerals. In the hunter-gatherer age the number of humans and their imprint upon the biosphere was minimal. Initially in the agricultural age the slash/burn and move when the soil was exhausted approach was often employed and the humans began to alter the biosphere. The agricultural age runout and the Industrial age greatly increased the breadth, scope and impact of humans upon the biosphere, now massively augmented by adverse impacts from human technologies. The totality of the human impacts upon the biosphere has been referred to as the Anthropocene, indicating human dominance. Basic ecosystem functionalities are being seriously degraded, including water regulation and purification, pollution impacts, filtering, waste sink effectiveness, soil retention, nutrient cycling, crop pollination, carbon sequestration, flood protection and waste decomposition [1]. Humans have altered climate and the ecosystem in many very negative ways, executed deforestation, desertification, vast pollution writ large (land, sea, air, space), and extensive urbanization along with species extinction, erosion, soil salination, ocean acidification, mining, water scarcity and the many adverse impacts of climate change. Climate change effects on the ecosystem include temperature rise, ocean level rise, storms, floods, disease, fires, species extinctions and ocean circulation changes. These issues have been exacerbated by a historically throwaway society, expansion of the human population, extracting too much from fixed biosphere resources, and the fossil carbon energy sources that fostered the industrial age. Climate is a prime example of a massive negative effect that society "assumed" the ecosystem would self-heal. Unbridled economic growth in an ecosystem with fixed resources is not possible. Current indications are that society is now short some half a planet in terms of traditional /historical capabilities and societal requirements [2]. Some half way through the year society drives the biosphere increasingly negative. Obviously, especially in terms of the human technology engendered effects, e.g., climate, pollution, etc. somethings major and serious have to be changed, and, overall, the "adverse" biosphere impacts of humans "mitigated" to reversed. The adverse ecosystem impacts are massive, planet wide, requiring mitigation approaches at the same scale. There has been much societal temerity regarding making such huge changes. The experience with the development of renewable energy is once the costs of the renewables were brought below fossil

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fuels, they became extraordinarily successful, are in the process of replacing fossil fuels—driven by profits. Hence it is reasonable to assume that fixing, mitigating the biosphere adverse effects will be more successful sooner if profitable. Profitable activities are usually taken up by industry and industrial initiation and execution is often sooner, more extensive and less expensive than government actions. Planet wide biosphere mitigation approaches are referred to as geoengineering or terraforming. Humans have been executing negative terraforming, altering the historical, prehuman, biosphere in huge and negative ways, and in the process degrading essential human biosphere derived functionalities/services. An alternative to the major current approach to "fixing" the biosphere, attempting to "put back" historical prehuman biosphere characteristics, is to adopt the current evolution of the humans-by-the-humans approach and design, craft an alternative biosphere go to state that is salubrious for humans—i.e., improve the Anthropocene. Emerging combinatorial frontier technologies are becoming available to execute such an alternative. There are two major classes of positive financial results from mitigating ecosystem and climate issues—Avoidance of costs and new profitable businesses [1]. These positive financial impacts include avoidance of major insurance, personal, productivity, commercial, and industrial losses due to climate change. Such losses occur due to flooding, storms, fires, rising sea levels, droughts, disease, heat and landslides. In addition there is avoidance of large adverse impacts on agriculture, fishing, health services, infrastructures, mining, supply chains, food systems, asset prices, and land and labor productivity. Cost avoidance involves personal, commercial, industrial, and agricultural losses due to diminishing topsoil, freshwater shortages, species extinctions, pollution and deforestation, reduced fish stocks, and reduction of natural resources. As an example there are some 9 million deaths each year from pollution which is 15 times the number of deaths from wars and 16% of global deaths per year. Pollution costs are $4.6 trillion on the global economy [3]. Ecosystem services vital to human well-being (e.g., crop pollination, water purification, food production, and carbon sequestration) have an estimated value of $125 trillion to $140 trillion per year [4]. The purpose of this article is to consider the spectrum of prospective approaches for ecosystem sustainability and climate mitigation going forward which scale to the planet wide scope of the problems and are potentially profitable and/provide cost avoidance. Traditional extant approaches/aspirations for these issues include a circular economy, recycling, reducing pollution, reforestation, and conservation. Refs. [5,6] discuss the interactions between the climate and ecosystems issues. The central theme of this work is that climate and ecosystem issues are wide spectrum, massive scale problems and their mitigation requires major causative and large-scale corrective changes. Such major changes will alter econometrics and society.

2. Materials and Methods

This work is the result of years of study regarding frontier power and energy, societal longer -term futures/foresight writ large, climate mitigation and frontier technologies writ large. This background, knowledgeability was mined to produce concepts which, at the planet wide, very diverse nature of the ecosystem issues, would be effective at scale and not only affordable, but often profitable. The profitable requirement concerns either cost avoidance or products and services and derives from the experience with the renewable energy development, where not much happened until the costs were driven below those of fossil fuel energy. The scope and diversity of the ecosystem problems are massive, and are rapidly developing into an existential societal problem. The attempt here was to posit, across this problem scale and diversity putative profitable solution spaces including those that require major societal and econometric changes.

2.1. Approaches to Mitigate Climate and Ecosystem That Are Profitable

Halophytes [7]**—**Fresh water is essential to human life and currently for food production. Agriculture now requires some 70% of the available fresh water. Planet water resources are some 97.5% saline and 2.5% "fresh"- 68% of the fresh water is tied up in glaciers, 30% in ground water, most of the rest in permafrost and the great lakes, Lake Baikal, a very small percentage of the total water is "available" fresh water. Usual approaches to the increasing water shortages due to the increasing population, climate and pollution issues are to improve utilization of the very small percentage of available fresh water. This is often expensive and far from curative given the increasing water requirements. Halophytes are "salt plants", the other portion of the plant kingdom. Thousands of halophytes grow on deserts, wastelands (44% of the land) and oceans/seas using saline/seawater (97% of the water), what we have a plethora of. Halophytes mimic most fresh water plants including food plants, there are halophyte tomatoes and rice. Quinola is a Halophyte. Macroalgae is a staple food in parts of the world. Their cultivation involves cheap land and cheap water, with seawater supplying some 80% of the nutrients, so minimal fertilizer. We have extracted so much fresh water from the aquifers that the water is becoming saline, we are salinating arable land. Halophytes sequester some 18% of their CO_2 uptake in deep desert roots pulling, at scale, 4 gigatons of CO_2 out of the atmosphere. Their cultivation would produce massive amounts of inexpensive food, biomass and biofuels, and in the process literally rapidly green the planet using available technology. Halophyte biomass could replace petroleum for chemical feedstock, obviating the petroleum used for such and provide biofuels for transportation. A switch to halophytes for food can save increasing portions of the 70% of the fresh water we are running out of that is now used in fresh water agriculture for direct human use. Overall, halophytes mitigate-to-solve land, water, food, energy and climate rapidly, at scale and produce major profits. Boeing is growing Halophytes for SAF, green aircraft fuels. Directly counters drought, desertification, could green Death Valley. Halophyte irrigation produces an unstable atmosphere and fresh water rain down wind.

Energetics [8,9]—There are a large number of green renewable energy sources which include wind, solar photovoltaics (PV), solar thermal, geothermal, ocean currents, ocean waves/tides and temperatures, osmotic power, hydro, and biomass. Energy storage approaches include batteries, pressure, heat, flywheels, and chemical changes. Transportation batteries are volume and weight limited, grid batteries are not. The renewables possess truly massive capacity, and technology has reduced their costs below fossil carbon energy and those costs are still dropping rapidly. Also, the costs and capabilities of storage are both greatly improving. A large percentage of new electrical generation is renewables and over 30% of world wide electric generation is now renewables. The outlook is for increasing distributed generation/storage at point of use will obviate eventually the many vulnerabilities of the grid along with grid losses and costs [10]. Renewables and storage scale with the climate problem and are profitable, hence their rapid development and application. The ongoing major conversion from fuels to electrics throughout the economy is a very significant development for ecosystem mitigation. Additionally, The Japanese have discovered LENR scaling to useful levels, creating weak nuclear force reactions with a measured 10,000 times chemical energy density and no radiation. They are commercializing long-lasting heat batteries from this technology with low costs and size/weight. The scaling cited by a Japanese firm is in the range which would essentially and inexpensively literally “solve climate” and reduce energy costs, increase operational range and greatly mitigate ecosystem issues, creating an “energy-rich” society [11].

Pollution/Waste—Pollution writ large, land, sea, air and space, is a direct result of the historical throw-away society. Environmental pollution is the worlds’ largest cause of untimely death and disease [12]. Pollution causes acid rain, respiratory effects, heart disease, lung cancer, damage to brains, nerves, kidneys and liver. Fossil fuels are the largest source of air pollution. Water pollution is caused by water dumping writ large, including fuel dumping, farming, deforestation, sewage and industrial waste. Water pollution causes contamination of the food chain and diseases including Cholera, Diarrhea, hepatis A, typhoid, and polio. Over half of the lakes and rivers in the U.S. are polluted. Fixing climate, shifting from fossil fuels will greatly alleviate air pollution. Stopping water dumping writ large, shifting to a reusable, circular economy would greatly mitigate water pollution, as would plant genomics to protect against insects and diseases. Space pollution, aka space debris is becoming serious, there are indications that we are a few collisions from closing out LEO (low earth orbit). There are efforts to deorbit or reutilize satellites in space going forward, the major issues are the huge current efforts to increase satellite numbers from a few thousand to many tens of thousands, and the many millions of debris articles in space now, some very sizable, and dangerous due to high velocities. Use of energized tethers instead of fueled rockets to capture and deal with derelict space objects would reduce the cleanup cost by a large percentage. Studies indicate that reuse of materials now dumped, including in land fills are a source of valuable materials [13].

Conservation and Efficiency [1,9]—The projected impacts of conservation, efficiency and energy loss regeneration are massive, some 44% reductions in energy use by 2040 and up to 60% by 2050. This approach has already flattened out the energy use growth curve. These approaches are cutting consumers energy bills, and mitigating climate and the ecosystem, in the process creating major markets for enabling products and approaches. There are now buildings that generate energy instead of using it, manufacturers are switching to electrification for econometrics and efficiency, electric motors use the greatest share of the energy and their efficiency is up by some 30%. The ongoing shift to tele-everything with less physical transportation has, using tele-shopping as an exemplar, a factor of some 15 less climate effects than physical shopping. Electric motors are some twice as efficient as the best thermodynamic/fuel using cycles. Overall, excellent markets for efficient, energy conservation techs, approaches and products. Going forward AI, data analytics, the emerging global brain fed by the web and the emerging global sensor grid, the switch from generating wealth from natural resources to generating wealth by inventing things with increasingly invention via AI should increase efficiencies and conservation beyond the current projections.

Climate Mitigation Approaches Potentially at Scale and Profitable [7–9,11]—Renewables and storage, once their costs went below fossil fuels, have become the major at scale and profitable climate mitigation approach. Additional at scale profitable renewables not yet fully-developed include high altitude wind and geothermal utilizing the millions of defunct, abandoned oil and gas wells. LENR if developed as envisioned would be a serious competitor for the extant renewables and provide distributed, at point of use generation even at scales below homes and factories including personal transportation. Halophytes with their massive capacity (44% of the land, 97% of the water) could sequester up to 4 gigatons of CO_2, provide massive amounts of inexpensive biofuels and replace the petroleum now used for chemical feedstock. Given the major impacts of human society upon the countryside, white roofs and white roads would usefully increase the planets albedo and cool buildings, projected estimates indicate these could delay climate by the order of a decade. There is a weak force nuclear battery developed by NASA that, if fed nuclear waste, could generate massive power on the grid [14]. Estimates indicate there is enough nuclear waste in the U.S. to power the grid for 100 years [15]. Ocean fertilization with iron dust has been shown to provoke algae blooms and ice core data from the ice age indicates high dust content and low CO_2. The algae blooms increase fish populations and the algae can be used for oil, protein and other products. Nascent climate mitigation approaches include fungi for CO_2 sequestration, they sequester 80% of their CO_2 uptake via symbiosis with plant roots, produce proteins and oils, 3 million species. Estimates indicate fungi sequester some 36% of global fossil fuel CO_2 emissions now, a subterranean carbon bank [16]. Then there is use of nano scale holes in material that generates electricity from humid air continuously which appears to scale well, another renewable that is base load, no storage required, also no fuel required. Use can be made of direct radiation to space for air-conditioning, an ever—increasing part of the energy load.

Cellular Agriculture—The usages of conventional agriculture including animal protein production create major ecosystem issues. Developing now from the ongoing bio tech revolution is cellular agriculture [17]. Initial manifestations in the market place of this is lab grown meat, other proteins. Utilizes molecular biologics, tissue engineering, synthetic biology and bacteria to craft an increasing spectrum of food products, from "factories", not farms. Other alternatives to conventional agriculture include cyanobacteria and insects. Then there are chemotropic single-celled organisms, termed dark foods [18]. Projections indicate these foods that do not use photosynthesis could result in factors of 4 plus reduced resource requirements compared to food production by photosynthesis. Such alternative agriculture approaches could obviate the major biosystem and climate issues due to utilization of animals and conventional agriculture for food. These approaches also have direct application to Humans-Mars exploration/pioneering and colonization.

Optimized Materials [19] Materials technology [20] contributes to increasing living standards, enhancing human experiences and addressing societal issues. Materials are critical for energy, transportation, health, housing and industry [21–25]. Materials science and technology includes their interactions, structure from the macroscale to subatomic scale and materials processing for nano, bio, electronic, optical, structural and magnetic materials including ceramics, glasses, composites, polymers, metals, semiconductors, along with "designer materials" [26]. Designer materials include aerogels, graphene, metamaterials, quantum dots, carbon nano tubes, multifunctional materials, and conductive polymers. Engineering materials properties of interest include acoustics, optics, chemistry, electrics, magnetics, manufacturability, mechanical behavior and thermal, Materials are the basis of nearly everything. Optimized materials would have lighter weight, multiple functionalities, be intelligent, durable, stronger, more easily processed, provide unique capabilities such as room temperature superconducting, and be recyclable. The current state of the art in this arena has been expensive, long-term R&D with often limited end state performance. Currently fast computing and advanced AI are enabling very rapid detailed study of material optimization for specific requisite capabilities, processing and utilization metrics via computational study of hundreds of thousands and more material combinatorials. These optimized materials should increase materials efficiency/usefulness/capabilities/recyclability and lower cost across the board with overall major ecosystem benefits.

Ocean Mining—Conventional mining has a long list of major negative impacts upon the ecosystem [27]. The ocean contains some 70 minerals and trace elements and the developing ever cheaper energy sources are making ocean mining ever less expensive. These minerals have eroded off the land into the oceans as long as there have been rivers and coastlines. Minerals available in the ocean include lithium, cobalt, copper, nickel, silver, gold, rare earths, diamonds, aluminum, manganese, uranium, titanium, chloride, sodium, calcium, bromine, phosphorus, tellurium, platinum, iron, magnesium, tin calcium, and magnesium. There have long been viable efforts to evaporate seawater and "mine" the resultant solids. As deep ocean mining is being seriously reconsidered there are several potential negative ocean ecosystem issues that need to be evaluated. Given the major adverse ecosystem effects of surface mining and the increasing societal mineral needs, increasing utilization of ocean mining, which is less expensive [28] should be efficacious, depending upon whichever/whatever of which has acceptable ocean ecosystem impacts.

Kite Wings—Due to climate impacts and pollution the oceans are going hypoxic to anoxic. The Ocean thermal-haline circulators are now dying. When this happened in the Permian extinction, the great dying, triggered by CO_2 emissions from Siberian volcanoes at some 1% of the current CO_2 emission rates, the oceans went anoxic, causing an overgrowth of cyanobacteria that produced much hydrogen sulfide which in parts per million is a poison. Overall, 94% species extinction. [29]. Currently we appear to be replaying the Permian, only much accelerated. One option to mitigate this is to oxygenate the upper ocean surface using ‘kite wings”. The flow over delta wings at angle of attack results in longitudinal vortices. Positioning them partially submerged at angle of attack and towing them with autonomous buoyant kites would entrain oxygen into the upper layer of the ocean. The delta wings and kites could be inexpensively constructed via printing manufacture in very large numbers and controlled by inexpensive sensors/electronics. The whole assemblage could be operated by solar energy and wind forces. The effects of this is also to somewhat reduce the ocean surface temperature, which could reduce the strength of hurricanes.

2.2. Societal System Level Changes to Mitigate Climate and Ecosystem Issues

The Virtual Age [30,31]—Human interaction has developed from smoke signals, flags, and mirrors to the telegraph, the telephone, early video and into augmented reality, virtual reality, and holographic projection, i.e., immersive presence/digital reality. This has enabled telecommuting, telework, teleshopping, tele-education, telemedicine, tele-politics, tele-manufacturing, telecommerce, and tele-travel. As a whole, development toward virtual worlds with developing direct projection into the brain, the enabling technology for the developing Metaverse. The web, the developing global sensor grid, and quantum computing, should enable the metaverse to increasingly replace physical travel and interactions. Recent AI progress has greatly increased these developing capabilities. Overall, the projection is for far less physical travel and associated energy/fuels and expensive transportation infrastructures which can produce flooding, desiccation and heat islands.

DIY Back to The Land [32]—Before the Industrial Age, most lived on the land in a do-it-yourself mode. The Industrial Age required factory workers which led to the expansion of cities and suburbs and associated ecosystem impacts. The Virtual Age involves technologies which would enable widespread back-to-the-future do-it-yourself independent living. Due to tele-everything the population can increasingly live wherever they want. The renewable energy developments are enabling distributed electricity generation and storage, so can go off wires. The electric personal air vehicles provide roadless physical transportation. Can grow significant amounts of food on a small holding, overall enabling roadless, wireless, independent living. The gig economy, where employment is usually via the web proffers at-home employment opportunities. Using carbon, hydrogen, and oxygen available on site, can manufacture and print plastics. Independent, tele-everything, off all the physical grids, living. Such a shift to independent DIY living would have major favorable impacts upon both climate and the ecosystem including those in manufacturing, finance, fossil fuels and service industries, along with proffering nearly jobless independent living, while greatly mitigating ongoing replacement of human labor by machines.

Redesigning the Ecosystem for The Anthropocene [33]—The ecosystem, biosphere literature has a central theme of positing the prehuman biosphere state as the ideal end state wrt mitigation approaches, “rewilding”. We are now in the Anthropocene, an ecosystem/biosphere condition largely and increasingly created/altered by humans. Unfortunately, usually via practicing negative terraforming, creating ever more and greater ecosystem issues. Adverse effects of technology contributed, especially wrt climate, to these issues. Given the massive set of frontier technological ongoing revolutions there is an opportunity now, at the scale of the issues and profitably, to posit technological fixes, mitigations to produce an ecosystem that is positive, for humans, terraforming and along the way seriously mitigating the many current societal biosphere issues. The initial step in redesigning/optimizing the ecosystem for human society is the definition of what that “go to” ecosystem should be, its characteristics, requirements, and overall compatibility with the strictures of a finite earth ecosystem. This design process is not yet a work in process but should perhaps include consideration of transhumanism, the ongoing evolution of more capable/longer lived humans by the humans and the development of AGI, alternative intelligent species. The current Anthropocene/human changes in the biosphere/ecosystem has and is causing species extinction as habitat is altered for human use/purposes. There are three major responses to dealing with species extinctions. The current approach, which is largely to attempt conservation and protect historical habitats as is reasonably possible, with an end point of zoo environments. Another is to observe how species are adapting to the human environmental changes, including those due to climate changes. Reporting indicates that in many cases species are adapting to such as urbanization and temperature increases, and moving as the habitat climate changes. The third approach would be consistent with human design of a human favorable biosphere vice the current, historical negative terraforming. This design wrt species could going forward involve creation, development of designer life forms that fit in well with a human designed Anthropocene, having characteristics favorable to humans—biosphere-wise.

2.3. Summary of Putative Technological at Scale Ecosystem/Climate Impacts

Halophytes—Profitably replaces fresh water for food and fodder, greens the planet, provides massive amounts of cheap biofuels, sequesters up to 4 gigatons of CO_2, productively utilizes soil salination, reduces ocean acidification, solves fresh water scarcity and desertification and deforestation.

Energetics—Profitably provides distributed electrical generation at point of use and universal electrification, obviates poles/wires/the grid, an "energy rich" society, solves the solar storm EMP (electromagnetic pulse) threat, mitigates ocean acidification.

Pollution—Combination of cost avoidance and profitability, circular economy, improves the ecosystem across the board.

Conservation/Efficiency—Profitable 50% plus reductions in energy use, mitigates climate much faster/much reduced CO_2 emissions, major mitigation of climate-caused adverse ecosystem impacts.

Augmented/Wide Spectrum Climate Mitigation—Several profitable nascent green energy approaches, CO_2 sequestration and "safe" geoengineering.

Cellular Agriculture/Dark Food—profitably solves methane from animals, provides massive amounts of low-cost foods and bioproducts, reduces adverse agricultural impacts on the ecosystem.

Materials—Profitably reduces weight across the board, possibility of room temperature superconducting for efficiency, reduced pollution from manufacturing.

Ocean mining—Profitable/less expensive mining, surface mining has major adverse ecosystem impacts.

Kite Wings—Cost avoidance, possibility of reducing the intensity of hurricanes and reducing-to-obviating the potential impacts of anoxic oceans.

Virtual Age—Cost reductions, much reduced physical transportation and associated adverse ecosystem impacts.

DIY Back to the land—Cost reductions, deurbanization, major pollution reductions, societal life changing.

3. Concluding Remarks

The near-termism/tactical nature of society has resulted in what are now becoming existential societal issues, including very adverse climate and ecosystem changes. The scale of these is planet wide, requiring corresponding mitigation approaches at the same scale. Also, such large-scale mitigation approaches are expensive and require societal changes. Such changes, due to the amygdala, are difficult to advance. This combination of change averse, and expense has thus far, except in one case, limited mitigation approaches to far less than the scale of the issues. That exception is renewables and storage, which began a huge growth period only when their costs were below fossil carbon fuels and nuclear reactors, i.e., large changes are apparently driven by profits. Serious mitigation of climate and ecosystem therefore would apparently be accelerated for those approaches that are at the scale of the problem, and profitable. There are several such approaches, that appear to be at scale and possibly profitable, summarized herein. Of these, the arenas of halophytes, energetics, tele-everything, laboratory foods, renewables and storage writ large and DIY living would have the largest profits and the greatest at scale favorable impacts upon the ecosystem and climate, but would alter much several major current econometric engines, including fossil fuel energetics, fresh water agriculture, and the auto industry. Recent experience indicates that, in the case of the fossil fuel industry, they are redirecting to renewables/storage, due to profits.

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Informed Consent Statement

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