

**A Systems View of Global Trends and Their Consequences**

Dennis Holeman  
Revised 16 July 2019

Trend area	Primary trends	First order effects	Second order effects	Third order effects	Fourth order effects	What has to be done, at minimum	
Environmental	Accelerated burning of fossil fuels (coal, oil, natural gas) with emission of greenhouse gases (particularly carbon dioxide and methane)	Increase in atmospheric temperature from greenhouse effect	Continued change in global climatic patterns	Continued increase in the severity of storms; more extreme weather in general More severe droughts in many areas	More severe flooding and storm damage (hurricanes, tornadoes, etc.) Bigger, more severe fires	<ul style="list-style-type: none"> <li>* Stop providing subsidies to fossil fuel industries</li> <li>* Phase out of the burning of coal</li> <li>* Phase out of the burning of natural gas</li> <li>+ Phase out the burning of oil</li> <li>* Provide CO2 capture and sequestration</li> <li>* Shift ground transportation (road, rail, etc.) to electric power</li> <li>* Insulate buildings with high efficiency insulation</li> <li>* Switch manufacturing processes to low carbon emissions (e.g., cement manufacture)</li> <li>* Generate electric power by solar, wind, wave, tidal, geothermal, hydroelectric, and other renewable systems</li> <li>* Provide electric energy storage systems (e.g., pumped hydro, hydrogen cycle fuel cells, etc.)</li> <li>* Minimize energy use of transporting water</li> <li>* Minimize energy loss in long-distance electric grids using high-voltage DC lines</li> <li>* Shift lighting to high efficiency LEDs</li> <li>* Shift building heating and cooling to high efficiency heat pumps</li> <li>* Capture hydrofluorocarbon refrigerants so they are not released</li> <li>* Provide low-cost systems for developing countries: rooftop solar, LED lights, high-efficiency cookstoves</li> <li>* Develop urban areas optimized for electric mass transit, electric bicycles, ridesharing, etc.</li> <li>* Relocate people displaced by coastal inundation, flooding, other climate change effects</li> <li>* Prepare vaccines in advance for tropical diseases</li> </ul>	
			Increased requirement for air conditioning	Energy use positive feedback loop			
			Melting of ice sheets (Greenland, Antarctica, etc.)	Rise in sea level positive feedback loop			
			Melting of Arctic sea ice	Reduced reflection of sunlight	Global warming positive feedback loop		
			Increase in ocean temperatures	Storm severity positive feedback loop	Destruction of coral reefs		Reduction in biological productivity
							Population migrations from unliveable coastal areas
			Rise in sea level	Inundation of coastal areas worldwide			
			Release of methane from high latitude permafrost	Global warming positive feedback loop			
			Loss of glaciers feeding major river systems	Shrinkage of river flows, water shortages	Reduced agricultural productivity in the watershed		
			Shift of regions able to grow particular crops to higher latitudes	Major shift in regional economies			
			Reduction in habitability of high-temperature regions (deserts, equatorial areas)	Population migrations from unliveable high temperature areas			
			Spread of diseases formerly confined to tropical areas	Likelihood of pandemics			
			Increase in acidity of the world's oceans	Reduction in biological productivity throughout the ocean food chain	Reduction in the ocean's production of oxygen		Decrease in amount of food obtained from fisheries
Increased oxygen stress worldwide	Reduced livability of higher altitude areas						
Accelerating loss of agriculturally productive land through development and damaging land use practices	Reduced ability to grow sufficient food and fiber for a growing world population	Food shortages and hunger			<ul style="list-style-type: none"> <li>* Severely limit conversion of prime agricultural land</li> <li>* Require appropriate non-damaging land use practices</li> <li>* Work to restore damaged land</li> </ul>		
Accelerating destruction of the world's forests--for timber, paper, and conversion to agricultural use	Decrease in carbon sequestration by forests Loss of plant and animal habitats	Accelerating extinction of plant and animal species			<ul style="list-style-type: none"> <li>* Institute effective international control of deforestation to reach sustainable harvesting levels</li> <li>* Require responsible use of wood and paper products</li> <li>* Aggressively recycle paper and wood items</li> </ul>		
Accelerating depletion of the world's fisheries	Decrease in amount of food obtained from fisheries	Food shortages and hunger			Institute effective international control of ocean fishing to reach sustainable harvesting levels		
Accelerating depletion and pollution of aquifers	Reduction in availability of potable fresh water	Thirst	Attempted migrations of populations to less water-stressed areas		<ul style="list-style-type: none"> <li>* Use water-efficient drip irrigation systems</li> <li>* Grow crops appropriate to the environment and water availability (don't grow cotton in the desert!)</li> <li>* Recycle water to the greatest degree possible</li> <li>* Prevent water pollution</li> </ul>		
		Use of polluted and unsafe water					
		Reduced agricultural productivity					
Accelerating pollution of the oceans, e.g. with plastics, industrial chemicals, and oil	Impact on all plant and animal life in the ocean	Reduction in biological productivity throughout the ocean food chain			<ul style="list-style-type: none"> <li>* Reduce single-use plastic packaging throughout</li> <li>* Pursue aggressive international work with pollution sources to eliminate pollution mechanisms and paths</li> <li>* Require better fishing practices to avoid loss of nets, gear, etc.</li> </ul>		
		Reduction in the ocean's production of oxygen	Increased oxygen stress worldwide	Reduced livability of higher altitude areas			

	Accelerating release of synthetic chemicals into the environment without confirmation of long-term safety	Complex negative impacts on health of humans and other species (cancers, endocrine disruptions, etc.)				Improve management of approval for synthetic chemical production and use
	Accelerating extinction of plant and animal species	Loss of many keystone species, such as pollinators	Massive disruption of ecosystem health	Potential collapse of many food production systems		* Develop international institutions to aggressively protect endangered species worldwide * Enforce anti-poaching, anti-bushmeat, anti-animal medicine measures
Consumption	Accelerating depletion of nonrenewable resources such as oil, gas, and key minerals and elements	Shift to ever lower grade materials sources (mines, wells, etc.) Future unavailability of key resources to meet needs	Increased cost and environmental damage for obtaining materials	Reduced availability of fertilizer for growing crops		* Design products for long life, reparability, and recyclability through their whole life cycle * Require producers to take back products at the end of their life for maximum recycling
	Accelerating consumption of meat, dairy, and eggs as societies become wealthier	Increased conversion of natural areas to rangeland Increased fraction of crop production used to feed livestock				* Develop cost-effective and consumer-acceptable lab-grown meat (equivalent to mammal, poultry, and fish sources) * Replace dairy with plant-based milk equivalents * Strongly encourage plant-based diets
Habitation	Continued coastal development	Vulnerability to inundation from rising sea level	Loss of habitability of many of the world's major coastal cities	Loss of use of most of the world's important ports	Interference with world trade dependent on ocean transport	* Cease further development in coastal areas that will be inundated * Plan for orderly movement inland
	Accelerating urbanization	Hollowing out of rural areas and small towns	Increase in rural and small town poverty and social dysfunction (drug addiction, alcoholism, suicide, etc.)			* Plan urban centers for the long term, including the effects of all the other changes occurring * Strive to create smaller regional centers with viable economic bases
		Concentration into megalopolises	Increase in slums next to high-rises			
	Increasing shortage of land available for constructing new housing in urban central areas	Accelerating increases in the cost of housing	Increasing homelessness			* Provide subsidies for developers to construct and maintain low-cost housing * Focus on higher density housing in urban areas
Lack of investment in maintaining infrastructure resources (roads, rails, bridges, airports, water systems, utilities, etc.)	Failing infrastructure				Require 100% reserve funding to maintain all infrastructure elements	
Demographic	Continued population growth, particularly in African areas (e.g., Nigeria, Congo, Ethiopia), and India, Pakistan, and Indonesia	Inability to grow sufficient food locally to feed the nations' populations Other major shortages	Food shortages and hunger Internal group conflicts	Attempted mass migrations of populations to less food-stressed areas	Intercultural/international conflict	* Provide effective family planning assistance * Promote small families * Educate women, provide meaningful employment for women
	Increasing lifespans	Increasing fraction of lifespan post-employment	Difficulty saving sufficient money for retirement	Elder poverty		Strengthen elder support systems (Social Security, Medicare, etc.)
		Increasing fraction of lifespan spent with physical and cognitive disability	Increasing caregiving needs for the elderly			Provide caregiving with adequate financial compensation
	Declining birth rates, falling below replacement in most of the developed nations	Declining number of workers supporting each non-working person	Inter-generational conflicts			Re-invent economic systems to accommodate negative growth conditions
		Aging of population age distributions (from pyramid to spindle to inverted pyramid)	Growing proportion of the population needing health services, elder care, etc.	Shortage of caregivers		Provide caregiving with adequate financial compensation
	Increasing untreated mental illness and substance abuse	Increasing homelessness	Increasing incarceration			Provide treatment of mental illness, mental disability, and substance abuse by means other than incarceration
Loss of cultural homogeneity in societies around the world from large numbers of unassimilated migrants	Backlash of cultural groups fearing loss of primacy and privilege	Intercultural conflicts, some turning violent			International coordination and support of migrations forced by habitability conditions	
Financial and economic	Accelerating financialization of the world's economic systems	Conversion of capital investment from productive uses to financial speculation	Companies using profits to buy back stock rather than invest in R&D or production capability			* Severely regulate corporate stock buy backs * Decouple executive compensation from short-term stock prices, use as metric long-term corporate health instead
	Requirement for continual growth in a capitalist system	Inability to service debt in a major contraction				Reinvent economics to mitigate pathological incentives of capitalism

	Accelerating growth in public and private debt	Insolvency of major institutions such as governments	Inability to pay obligations, likelihood of defaults	Potential for system-wide economic collapse		* Stop using debt to pay for things like military expansion and adventurism * Stop using debt to fund consumption in excess of income
	Underfunded pension systems from over-optimistic investment return projections	Inability to pay pension obligations				Require realistic assumptions for investment returns for all pension systems
	Rapidly rising general costs of living relative to income	Accelerating economic disparity between the very rich and everyone else	* Increasing desperation of low-earning populations * Increasing economic precariousness of everyone	Increasing homelessness		Fundamentally re-invent the basic economic order
	Accelerating consolidation of multinational corporate monopolies	Corporate dominance of governmental policymaking	Erosion of political freedom			Return to aggressive prevention of monopolies and trusts
			Removal of regulation of corporations			Focus on smart regulation, considering all long-term impacts and consequences
		Shift of taxes away from corporations	Reduced government tax revenues	Spiraling growth in public debt	Cutbacks in government spending on services, etc.	Re-establish previous tax rates on corporations, close loopholes, provide effective monitoring and enforcement
	Economic globalization	Shift of production to the lowest cost areas (labor, environmental protection, etc.)	* Loss of jobs in high cost areas * Abuse of labor in lower-standard-of-living areas * Environmental degradation in low-regulation areas			International institutions with the authority and power to regulate multinational corporations to prevent abuses
	Increasing corporate focus on maximizing shareholder value, to the exclusion of all other considerations	Corporate pathologies				* Redefine corporate charters to require serving the public interest * Decouple executive compensation from short-term stock prices, use as metric long-term corporate health
	Accelerating replacement of jobs by various forms of automation and machine intelligence	Increasing fraction of the population unable to find employment providing a living income	Decreased demand for goods and services as customers lack the income from employment to pay for them	Economic contraction	Positive feedback loop	Reinvent economics to provide purchasing power to those displaced from income by automation
		Accelerating cognitive and education qualifications required to be employable				
	Accelerating increases in the cost of education	Crushing debt to obtain a college education	Inability of young people to marry, start families, buy homes, etc.	A whole generation unable to join the middle class		* Provide really effective online education * Eliminate for-profit educational institutions * Incentivize cost-effective education delivery
	Accelerating increases in the cost of health care	Reduced fraction of population covered by health insurance	Increased bankruptcies from medical costs			* Shift to a single-payer health insurance system * Heavily regulate health care providers, incentivize cost-effective health service delivery
Military	Retention of nuclear weapons by the nuclear powers, particularly weapons on alert	Risk of nuclear weapons exchange through accident or miscalculation	Potential for full-scale nuclear war			* Establish that nuclear weapons are <b>only</b> for deterrence against a nuclear first strike * Eliminate all nuclear weapons vulnerable to pre-emptive strike (e.g., missiles in fixed land-based silos) * Ban missile defense systems * Take nuclear weapons systems off ready alert * Develop international agreements to phase out nuclear weapons altogether
	Retention of biological weapons capabilities	Risk of use of biological weapons by a nation or group under pressure	Risk of mass deaths from human-created pandemics			Develop international agreements to destroy all biological weapons capabilities
	Increasing development of offensive cyberwarfare capabilities	Shift in conflicts to non-kinetic attacks				Develop international agreements prohibiting cyberwarfare, with serious sanctions for violations
	Accelerating development of autonomous lethal systems					Develop international agreements prohibiting autonomous lethal systems
Technological	Continued buildup of radioactive waste without safe means for long-term storage	Potential for severe radioactive contamination incidents	Potential for rendering large areas uninhabitable			Develop international safe long-term nuclear waste storage facilities, move all waste to them

	Continued operation and construction of nuclear power plants	Potential for reactor accidents, particularly for poorly maintained or abandoned plants				Phase out existing nuclear power reactors, abstain from building new power reactors, safely dismantle obsolete systems
	Unremediated contamination by nuclear materials, particularly those from nuclear weapons fuel processing and weapons testing					Prioritize cleaning up nuclear contamination sites worldwide
	Increasing global reliance on single-point-of failure-systems, such as the Global Positioning System, for essential infrastructure functions	Potential for massive breakdown (e.g., of global electrical and telecommunications grids)	Likely inability to recover			Create effective backup systems
	Increasing vulnerability of electronic systems to cyberattack, electromagnetic pulse, solar flare event, etc.	Potential for widespread disruptions	Likely inability to recover			Mandate multifunctional hardening for critical systems
General political	Oligarchic control of governments by wealthy interests (corporations and high net worth individuals)	Inability of the public to influence government policy	Further consolidation of wealth and power; positive feedback loop			* Put through campaign and election finance reform * Repeal Citizens United * Severely limit lobbying contributions
	Ubiquitous surveillance, by both governments and corporations	Ability to detect dissent, disagreement, and resistance at the earliest stages	Potential for tyrannical societal control			Pass legislation to greatly restrict citizen surveillance
	Deep fake photos, video, and audio and other disinformation	Inability of the public to determine what is real in the news				Provide serious penalties for distributing malicious deep fakes
	Worldwide drift towards right-wing nationalist authoritarianism					Push back against authoritarian trends
	Privatization of functions formerly performed by governments--e.g., prisons, water systems, education, etc.	Transfer of public wealth into private hands	Positive feedback loop--increased power of private interests			Establish strong principles for what is and is not appropriate for privatization
	(More TBD)					
U.S. political	Shrinking U.S. influence, growing influence of other societies and cultures (particularly China)	Attempts to hold on to position through increasingly desperate measures				Accept a multipolar world; give up the need to dominate; focus instead on leadership for solving the problems facing all
	Drive for military supremacy and dominance; military adventurism	Ruinously expensive actions				Create strong citizen demand to re-cast national policies and goals
	Growing trade imbalance					* Institute consumption taxes * Tax capital inflows * Incentivize savings * Switch the world off the U.S. dollar as the global reserve currency
	Increasing dissemination of ideological propaganda by media [e.g., Fox News, right-wing talk radio in the U.S., websites, etc.]	Distortion of public beliefs and attitudes				(TBD)
	Accelerating societal polarization	Reduction in ability to compromise and cooperate				(TBD)
	Increasing white nationalism and racism	Potential for internal violence				(TBD)
	Political exploitation of grievances					(TBD)
	Widening societal inequalities					(TBD)
	Untrustable elections, e.g., due to cyberhacking, vote suppression, etc.	Loss of political legitimacy				* Require unhackable election mechanisms overseen by truly independent agencies * Address vote suppression
	(More TBD)					