Overcoming Global Pressures to Achieve a Healthy, Resilient and Sustainable Society

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Abstract

The economic prosperity and well-being of modern societies is threatened by a number of interrelated megatrends, including population growth, climate change, resource depletion, urban infrastructure decline, and increase in extreme weather events. It is urgent that government and business recognize and accept these threats and work together to meet the challenges they pose. Without that, efforts to enhance economic growth, protect human health and achieve a resilient and sustainable society will never be successful. This paper summarizes the linkages among these megatrends, especially related to food, energy, and water production. Overcoming these problems requires supplementing existing environmental legislation through application of key technologies and enhancement of stakeholder engagement and collaboration. The Environmental Protection Agency (EPA) is a key player in the application of science and technology, and in building partnerships to work with states, cities, and local communities to effectively develop and apply science and technology to protect human health and the environment. Working alongside the business world, EPA activities are also critical to enhancing economic growth and building a resilient and sustainable economy. Since its establishment, the Agency's role has evolved from regulator to innovator. As the Agency turns 50 in 2020, it will continue to enhance society and be an "Economic Productivity Advocate" as much as an "Environmental Protection Agency."

Keywords: Megatrends, resilience, sustainability, systems thinking.

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1. Introduction

"We're experiencing a time in which human society and technology are ***increasing the pace and rate of environmental change in ways for which no precedent exists****, and which have significant potential consequences."*

The above quote is from a 2015 Report of the National Science Foundation (NSF) Advisory Committee describing major challenges impacting the health and well-being of society today.[1] The pace and rate of change reflects the results of a number of global trends such as population growth (especially in urban areas), climate change, resource depletion, and increase in extreme weather events. These stresses impact major cities as well as rural communities, and challenge both government and business to achieve and maintain a resilient and sustainable society.

Resilience is defined by Presidential Policy Directive 21 (2013) as the "ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions." [2] Sustainability as defined by the National Research Council (2011) is both a goal and a process that enables us to meet our environmental, social, and economic needs today without compromising the ability of future generations to meet their needs. [3] The traditional definition of sustainability as outlined in the 1970 National Environmental Protection Act (NEPA) is the ability "to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic and other requirements of present and future generations of Americans."

While sustainability focuses on improving long term conditions, resilience focuses on overcoming urgent short-term challenges that may hinder progress toward long-term goals. A key element of both resilience and sustainability is protecting human health—a topic highlighted throughout this paper.

Cities and communities are critical focal points for pursuit of both resilience and sustainability. Urban communities are currently placing rising pressures on natural resources and aging infrastructure, and facing increasing environmental risks that threaten to undermine the protection of human health. A number of recommendations for dealing with the current changing nature of urban problems is outlined in the 2016 National Academy of Sciences (NAS) report, "Pathways to Urban Sustainability." [4] The Report urges that "Urban leaders and planners should be cognizant of the rapid pace of factors working against sustainability and should prioritize sustainability initiatives with an appropriate sense of urgency to yield significant progress toward urban sustainability."

Addressing the pace and magnitude of changes affecting cities and communities requires actions that build on classic regulatory controls such as the Clean Air and Clean Water Acts of the 1970's. While such legislation remains important to set a minimum national response, what is needed today is: (1) innovation based on science and technology, (2) stakeholder engagement and collaboration, and (3) public education and support. Problems are best addressed when all stakeholders understand the full impacts and together cultivate common approaches to problem-solving.

Past and existing U.S. legislation has led to significant and lasting progress protecting the environment and safeguarding public health, all during a time of historic levels of economic growth and prosperity that the United States has enjoyed over the past four-plus decades. But legislation alone will not keep pace with current trends. Innovation is crucial for meeting the challenges of reducing humanity's global footprint and decoupling economic growth from adverse environmental impacts. Science can help to anticipate problems, devise effective and efficient solutions, and support decision-making. Innovation research, particularly coupled with integrated systems thinking, is now needed for us to understand the full scope of environmental, social, and economic problems.

The combined impacts of megatrends affect both business and government, and hence collaboration between businesses and Federal, state, and local government organizations is needed to address problems related in the areas of manufacturing, food production, energy supply, and water resource management. At the same time, public understanding of megatrends, how they are interrelated and how they affect human and community well-being is crucial in establishing a foundation for government and business support and bipartisan cooperation.

This paper discusses the growing number and pace of present and future trends that impact community well-being, and illustrates key science and technology advances needed to create a resilient and sustainable future. The paper ends with a discussion of the role and evolution of EPA in addressing contemporary problems and preparing for its 50th anniversary in 2020.

2. Megatrends Impacts Our Lives

A 2017 National Intelligence Council (NIC) report, "Global Trends Paradox of Progress," outlines a large number of stresses currently threatening our health, economic prosperity, and social well-being. [5] In that report, the NIC, which provides the Central Intelligence Agency with long-term strategic analysis, builds on their 2012 "Global Trends 2030" and reinforces the urgency of dealing with a variety of megatrends related to health, the environment, and natural resources.

The report notes that nearly all of the Earth's systems are undergoing natural and human-induced stresses "*outpacing national and international environmental protection efforts."* This is a major challenge for government and business. The Report also notes that "*Institutions overseeing single sectors will increasingly struggle to address the complex interdependencies of water, food, energy, land, health, infrastructure, and labor."* This point is addressed below in our discussion of the food-energy-water nexus.

Related to health and the environment, the NIC Report notes that:

- More than 80 percent of urban dwellers are already exposed to air pollution that exceeds safe limits and without the implementation of new air quality polices outdoor air pollution is projected to be the top cause of environmentally related deaths worldwide by 2035.
- Half of the world's population will face water shortages by 2035. Rising demands from population growth, greater consumption, and agricultural production will outstrip water supplies, which will become less reliable in some regions from groundwater depletion and

changing precipitation patterns. More than 30 countries—nearly half of them in the Middle East—will experience extremely high water stress by 2035, increasing economic, social, and political tensions in an already volatile area.

- Melting sea ice and glaciers will present new challenges. For example, melting ice in the Arctic and Antarctica will accelerate sea level rise over time. An increasingly navigable Arctic will shorten commercial trading routes and expand access to the region's natural resources in the decades ahead. Glacier melting in the Tibetan Plateau—the source of nearly all of Asia's major rivers—will also have far-reaching consequences.
- More than a third of the world's soil—which produces 95 percent of the world's food supply, is currently degraded—and the fraction will probably increase as the global population grows. Soil degradation, the loss of soil productivity due to primarily human-induced changes, is already occurring at rates as much as 40 times faster than new soil formation.
- A growing number of countries will experience water stress—from population growth, urbanization, economic development, climate change, and poor water management—and tensions over shared water resources will rise.
- Biological diversity will continue to decline despite ongoing national and international efforts to protect species. Climate change will increasingly amplify ongoing habitat loss and degradation, overexploitation, pollution, and invasive alien species— adversely affecting forests, fisheries, and wetlands. Many marine ecosystems, particularly coral reefs, will face critical risks from warming and acidifying oceans.
- Human and animal health will increasingly be interconnected. Increasing global connectivity and changing environmental conditions will affect the geographic distribution of pathogens and their hosts, and, in turn, the emergence, transmission, and spread of many human and animal infectious diseases. Further, unaddressed deficiencies in national and global health systems for disease control will make infectious disease outbreaks more difficult to detect and manage, increasing the potential for epidemics to break out far beyond their points of origin.

The cumulative effect of these stresses is clearly a threat to human health. Air pollution is growing worse in urban areas across much of the globe, affecting the poorest city dwellers most heavily, and contributing to a wide range of potentially life-shortening health problems. Today, especially in countries such as China and India, some 3 million deaths a year are linked to exposure to outdoor air pollution. The major sources of air pollution include inefficient modes of transport, household fuel and waste burning, coal-fired power plants, and industrial activities. Some pollution can also be influenced by dust storms, particularly in regions close to deserts. A recent article in *The New York Times*, "India's Air Pollution Now Rivals China as Deadliest in the World," (2017) notes that an estimated 1.1 million people per year are now expected to die prematurely. [6] Rising pollution in the developing world is clearly a result of industrialization and reflects the need for clean and green technologies.

China and India today are in many ways like the U.S. in the 1970s when EPA was first created in response to a growing public outcry for government action in the face of obvious serious air and water pollution events. Since that time, the country has made dramatic improvements to air and water quality and implemented programs and enforcment policies to continue to monitor the environment and take corrective action to protect public health. For example, under the Clean Air Act EPA regularly assesses six "critical air pollutants" known to impact health risks. [7] The pollutants include carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO2), ozone (O3), particulate matter (PM), and sulfur dioxide (SO2), as well as a large number of compounds that have been determined to be hazardous, called air toxics. The EPA continues to work with state, local and tribal governments, other federal agencies, and stakeholders to reduce air pollution and protect human health. Over the past decades, the combined efforts of legislation, pollution prevention, and technological innovation have vastly improved air quality in the U.S. Though air pollution problems have not been eliminated, such efforts have been linked to significant improvements in public health.

Today, we need to look beyond the impacts of specific pollutants and account for the combined effects of the megatrends that can compromise the health and well-being of our communities. The dominant megatrends of concern for U.S. cities are:

- **Population Growth in Urban Communities.** In 2008, for the first time in history, more people lived in urban areas than in rural areas. The pace of urbanization continues to increase, and today in the U.S. more than 80 percent of the population lives in urban areas. By 2050, global population is expected to increase by 38%, from 6.9 billion in 2010 to 9.7 billion, placing significant pressure on water, energy, and food resources. [8]

- **Impacts of Climate Change on Human Health.** Global governments have faltered in their efforts to mitigate carbon emissions, and today we are not preventing climate change, but instead adapting to it. [9] Climate change is already having substantial impacts on economic and social well-being and can get worse as greenhouses gases increase in the atmosphere. Severe droughts in the western U.S. over the past decade have resulted in the driest conditions in 800 years. Heat waves have become more frequent and intense, with 2011 and 2012 experiencing almost triple the long-term average. The health-related problems caused by air and water pollution are exacerbated by climate change; for example, it is projected that air pollution and airborne allergens will likely increase, worsening allergy and asthma conditions. Future ozone-related human health impacts attributable to climate change are projected to lead to hundreds of thousands of premature deaths, hospital admissions, and cases of acute respiratory diseases. [10] At the same time, summer extreme heat is expected to cause an increase in the number of premature deaths, from thousands to tens of thousands, which will outpace projected decreases in deaths from extreme cold.

- **Increase in Extreme Events and Natural Disasters.** Climate change is a key factor in increasing the number of extreme weather events. Between 2004 and 2014, natural disasters caused $1.4

trillion in damage globally, affecting 1.7 billion people and resulting in the death of 700,000 people. [11] This 10-year period accentuated a dramatic increase in the costs of natural disasters over the past 50 years. The U.S. experienced more disasters over this period than any other country except China. The 2015 UN Global Assessment Report predicts that disasters are expected to cost the global community up to $300 billion annually in the coming decades.

- **Human Vulnerability and Impacts on Disadvantaged Communities.** The U.S. population is growing, aging, and diversifying. It is projected to grow by more than 60 million over the next 25 years, and the percentage of the population over the age of 65 is expected to increase from 15 percent in 2014 to 22 percent in 2040. [12] Economically disadvantaged individuals and communities have always been more vulnerable to natural hazards, and in the U.S. poverty rates have been growing. The ability of cities to respond to disadvantaged communities is a critical challenge, especially in regard to future trends. EPA has prepared a 2020 "Environmental Justice Action Plan" to help disadvantaged communities achieve a healthier, cleaner, and more sustainable society. [13] The Plan was developed based on stakeholder input representing present and future environmental challenges facing American communities. It emphasizes the importance of infrastructure planning and design for all economic sectors and the application of tools and approaches for building resilient and sustainable cities.

- **Infrastructure Needs.** It is now clear that urban infrastructure is in serious decline. By 2030, as noted by the Rockefeller Foundation, approximately 75% of U.S. infrastructure will either need to be renovated or be built from scratch. [14] The "Build America" program—jointly launched by the White House and the Rockefeller Foundation—encourages a forward-thinking approach to infrastructure planning and investment. It enables the Federal government to partner with local and state governments as well as the private sector in order to create infrastructures that are resilient to disasters and disruptions. The required investment for underground drinking water infrastructure alone is estimated to be more than $1 trillion nationwide over the next 25 years, assuming that pipes are replaced at the end of their service lives and systems are expanded to serve growing populations. [15]

- **Land Use Change and Growing Ecological Footprint.** Driven by global population growth and associated demands for food and energy, as well as evolving consumption patterns, the pressure on the Earth's ecosystems is continuously increasing. Despite some positive developments, such as a recent reduction in the rates of tropical deforestation, global biodiversity loss and ecosystem degradation are projected to increase. The internationally-recognized Global Footprint Network has estimated that if current trends continue, by the 2030s, we will need the equivalent of two Earths to support the world's population. [16]

In dealing with these megatrends, business and government leaders have come to recognize that population growth, economic growth, climate change, and resource consumption are all interrelated, and required an integrated systems approach to

achieve and sustain long term public health, economic vitality, resource availability, and the continued viability of the ecological life-support systems on which we depend. The complexity of these trends also underscores the need for broad stakeholder engagement, business-government collaboration, and increased public understanding. One area where this is evident is in the nexus of food, energy, and water security.

3.0 The Nexus of Energy-Food and Water

The NIC 2017 study cited above points out that "institutions overseeing single sectors will increasingly struggle to address the complex interdependencies of water, food, energy, land, health, infrastructure, and labor." In particular, it is essential to understand the interdependencies among food, energy, and water, since rapid growth in population is causing increased demand for those resources. It is estimated that with a population of 8.3 billion people by 2030, society will need 50% more energy, 40% more water, and 35% more food. [17]

Highlighting the importance of this issue, the National Center for Science and the Environment (NCSE) organized a conference in 2015 on the "Nexus of Food Energy and Water." The Conference identified several critical questions:

1. How do we feed a projected global population of 9.6 billion people in 2050 while meeting their needs for water and energy and improving the environment?
2. What are the opportunities to improve water and energy efficiency and reduce food waste such that every improvement in one area yields gains in all areas?
3. What are the strategies for resilience in the face of increased climate variability and other environmental changes?
4. How do we develop wise public policy to unleash scientific talent, technological advances, human ingenuity, and entrepreneurship in order to meet essential human needs and restore the Earth's environment, both regionally and globally?

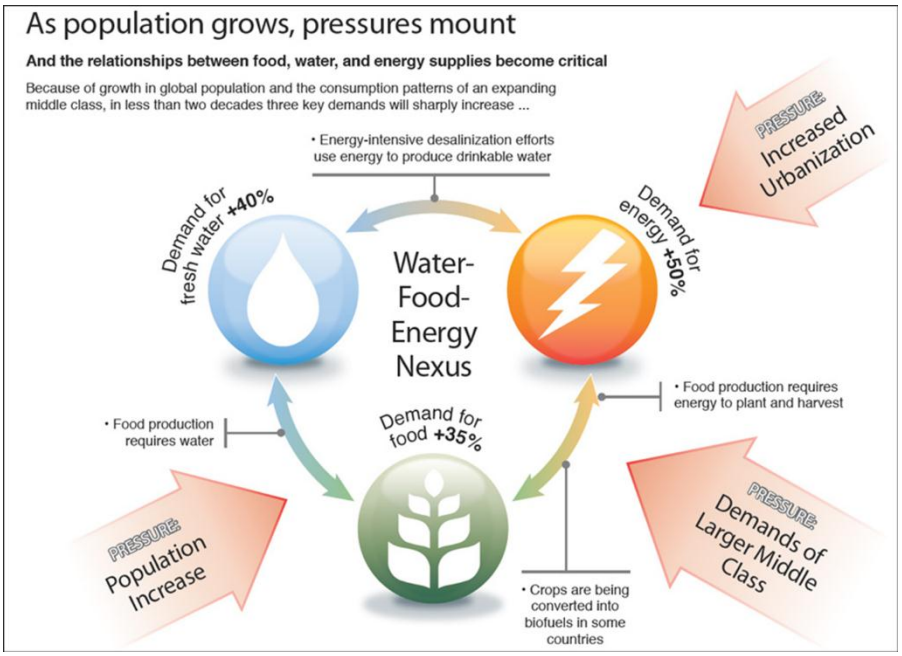
Energy and water are closely linked, since water is used in every phase of energy production and electricity generation. Water is an input for producing agricultural goods in the fields and along the entire agro-food supply chain. Energy is required to produce and distribute water and food: to pump water from groundwater or surface water sources, to power tractors and irrigation machinery, and to process and transport agricultural goods. Agriculture is currently the largest user of water at the global level, accounting for 70% of total withdrawal. The food production and supply chain accounts for about 30% of total global energy consumption. [18]

The nexus of food, energy, and water systems (see Figure 1) underscores the urgency of

Providing innovative management at all levels of business and government. This challenge has been recognized by the National Council on State Legislatures (NCSL) which has found that State legislatures and natural resource managers have traditionally addressed water and energy as two separate issues. [19]

Figure 1. The Food-Energy-Water Nexus.

Illustration from https://makewealthhistory.org/2014/05/30/the-water-food-energy-nexus/.



However, they have now come to understand that water and energy are deeply connected and sustainable management of either resource requires consideration of the other. Thus, resource managers and lawmakers across the country are beginning to take a comprehensive and interdisciplinary approach to the management of water and energy.

The nexus of food, energy and water is also evident to Federal agencies, several of which are advancing new programs and initiatives. The Department of Energy's (DOE) effort on Water-Energy Nexus has identified six pillars to address: [20]

1. Optimize the freshwater efficiency of energy production, electricity generation, and end use systems.
2. Optimize the energy efficiency of water management, treatment, distribution, and end use systems.
3. Enhance the reliability and resilience of energy and water systems.
4. Increase safe and productive use of nontraditional water sources.
5. Promote responsible energy operations with respect to water quality, ecosystem, and seismic impacts.
6. Exploit productive synergies among water and energy systems.

The National Science Foundation (NSF) has also launched a new program, "Innovations at the Nexus of Food, Energy, and Water Systems" (INFEWS.) The thrust of the new research program strongly emphasizes that

increasing the efficiency of resource use will require a systems approach to problem solving and solution development. The program also recognizes the need for greater interdisciplinary training for skills in complex systems modeling. This grant program will:

- Support integrated experimental research towards creating a comprehensive food-energy-water sociotechnical systems model;
- Advance knowledge/technologies that foster safer, more secure, and more efficient use of resources within the food-energy-water nexus, and
- Support an integrated approach to build the next-generation INFEWS workforce.

On the scientific and regulatory side, the EPA is pursuing multiple activities to enhance efficient use of water and energy, developing a systems approach to water-energy use, and creating decision support tools to help decision makers understand consequences of proposed actions. EPA's ENERGY STAR and WaterSense are two key labelling programs that advance efficient resource use. The Agency's efforts are stimulating system-level energy and water efficiency by water, wastewater, storm water and energy utilities and encouraging strategic investments in efficiency. EPA also aims to reduce the impact of energy generation on water quality and quantity, including reduced consumption or use of water for energy generation and fuel production.

Applying a systems approach to the nexus of food, energy, and water systems raises many challenges to science that are being addressed by scholars with diverse backgrounds and skill-sets. These challenges include:

- **Consideration of scale.** Each type of problem may require a different scale of analysis—a farm or factory, a city, a watershed, a nation, or the entire world. Similarly, time scales of minutes to hours are important for operational decision makers, while resource managers need to think in terms of years to decades.
- **Selection of metrics**. Appropriate metrics are needed to inform, guide, and facilitate understanding by various stakeholder's groups, and to enable effective decision making while recognizing limitations in data, time, and computational resources.
- **Data availability**. Data constraints that can hinder scientific progress include cost, political boundaries, access, transparency, compatibility, and scale of collection.
- **Model selection**. Complex problems require sophisticated models, and there is a continuing proliferation of available models that yield more or less useful outputs. However, increasing model complexity creates challenges in terms of data requirements, computational resources, and propagation of uncertainty.
- **Behavioral issues**. Human behavior and adaptation to change is perhaps the most difficult aspect of the resource nexus challenge. For example, conflicts over control of food, energy and water systems are common, depending on the environmental and social context. Differing perceptions of risk and benefit can result in unpredictable behavior, thus complicating the transition from useful science to effective decision-making. Multiple disciplines are needed to understand these issues, including law, policy, economics, anthropology, and political science.

4.0 System Science and Decision Support Tools

A key step toward developing a resilient and sustainable society is the ability to assess the unintended consequences of proposed actions and to help decision makers balance complex priorities. This requires a systems thinking approach, such as the one presented in Figure 2 portraying the dynamic linkages between economic, social, and environmental systems. (Fiksel, 2015). This conceptual model has been used by EPA to support "triple value simulation" efforts, which analyze the problems of food, energy, water, waste, land use, and economic growth from a broad regional perspective.

Figure 2. A dynamic view of economic, social, and environmental systems

One key element of EPA science is working with communities to develop and apply a wide variety of tools to improve environmental conditions, economic opportunity and human health. The linkage between tools and megatrends is outline by Hecht et al (2016.) [21] One example is the Enviro Atlas which is an interactive tool that helps communities better understand the potential benefits and drawbacks of their decisions by demonstrating relationships between nature, health, and well-being, and the economy. The Enviro Atlas contains hundreds of data layers and presents high-resolution data at national and community scales. Using Enviro Atlas, users can access, view, and analyze diverse information, such as pollution removed by tree near children under 13, to better understand the potential impacts of various decisions. [22]

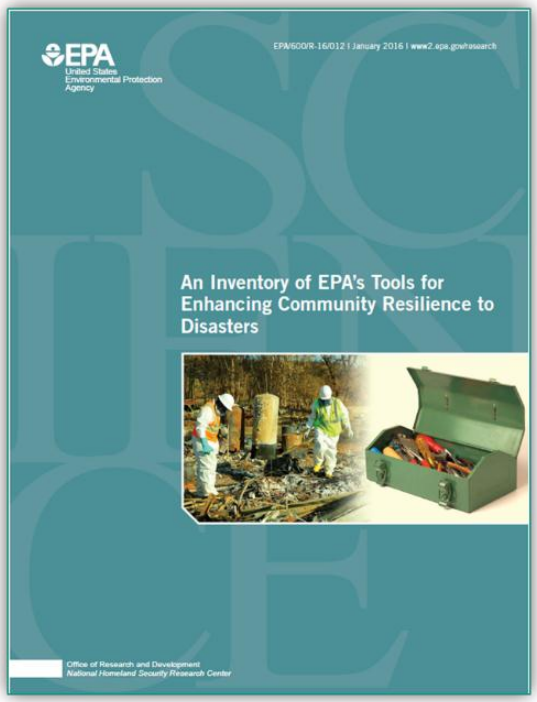
Another example of systems thinking is the business world's adoption the "circular economy" and "cradle to grave" concepts. A circular economy aims to promote greater

resource productivity while reducing waste and pollution. The G-7 nations, including Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States, are working together to advance resource efficiency, which is deemed vital for economic growth, competitiveness of industries and social well-being. A related concept is "sustainable materials management," which strives to manufacture products through economically-sound processes that minimize negative environmental impacts while conserving energy and natural resources. [23] These approaches aim to achieve greater economic benefits, less use of resources and hazardous chemicals, and less waste and emissions produced through manufacturing activities, ideally by creating industrial nutrient cycles that reuse non-renewable resources harmlessly and in perpetuity like natural water or nutrient cycles. The basis of these methods is understanding the foundational science of current and potential future production processes.

Beyond the application of system thinking and recognizing the pressures of mega trends, EPA has developed an extensive set of indicators and tools to help decision makers better understand the impact of proposed actions. One example is current EPA work creating an "Environmental Quality Index" (EQI) for all counties in the U.S., taking into account multiple factors that influence exposure and health—air, water, land, the built environment, and socio-demographic patterns. The EQI incorporates data representing the chemical, natural and built environments, and is intended as a composite environmental indicator that correlates to factors affecting public health. Use of the EQI will help researchers investigate the cumulative health impacts of many diverse environmental domains. [24]

EPA is also working to advance the concept of "environmental resilience" defined as "minimizing environmental risks associated with disasters, quickly returning critical environmental and ecological services to functionality after a disaster, while applying this learning process to reduce vulnerabilities and risks to future incidents." In support of Environmental Resilience as defined above, the agency has developed an "Inventory of EPA's Tools for Enhancing Community Resilience to Disasters," (see Figure 3) which reviews and summarizes many of the tools available to federal partners, states and local governments, utilities, communities, and individuals to help build resiliency to disasters. [25]

Figure 3. Inventory of EPA Tools



These tools can be directly applied for purposes of preparing for, mitigating, preventing, responding to, recovering from, and improving overall community resilience to all hazards, both natural and man-made disasters. These tools include online mapping systems, guidance documents and publications, and many others. Several of the tools were originally developed for recovering from chemical, biological, radiological, or nuclear events but can be used for recovering from other events as well. These tools are intended to provide researchers and practitioners with information that can be used to help communities protect their resources and become more resilient to potential hazards.

EPA has also created a new focus on Building Blocks for Sustainable Communities responding to many communities around the country who are asking for tools to help them achieve their desired development goals, improve quality of life, and become more economically and environmentally sustainable. [26]

EPA also provides technical assistance to selected communities using a variety of tools that have demonstrated results and widespread application. The purpose of delivering these tools is to stimulate a discussion about growth and development, respond to existing pressures, and strengthen local capacity to implement sustainability approaches.

These and many other tools can help communities to better prepare for a future that will be affected by the megatrends of climate change, population growth, and increases in extreme weather events. For example, resilience is critical in dealing with a variety of water-related stresses including drought and watershed management, stormwater and flood management, sea level rise and coastal erosion, water contamination, and aging infrastructure. EPA tools that can help build resilience in water resources include:

- CANARY and TEVA-SPOT: Provides early warning and detection of harmful contaminants in drinking water distribution systems. https://www.epa.gov/homeland-security-research/models-tools-and-applications-homeland-security-research.
- Community-Based Water Resiliency Tool (CBWR): Helps water utility personnel gauge current preparedness efforts and increase community awareness of the importance of including the water sector in emergency planning. https://www.epa.gov/communitywaterr

esilience/community-based-water-resiliency-tool.

- Emergency Water Supply planning guidance: Provides guidance on how to plan for disruptions in drinking water services. https://www.epa.gov/waterutilityresponse/water-utility-planning-emergency-drinking-water-supply.
- Climate Resilience Evaluation and Awareness Tool (CREAT): Allows water utility stakeholders to explore long-term impacts of climate change and adaptation strategies. https://www.epa.gov/crwu/build-resilience-your-utility.

EPA has also developed a "Water Infrastructure and Resiliency Finance Center" to help communities across the country improve their wastewater, drinking water, and stormwater systems, particularly through innovative financing and building resilience to climate change. [27]

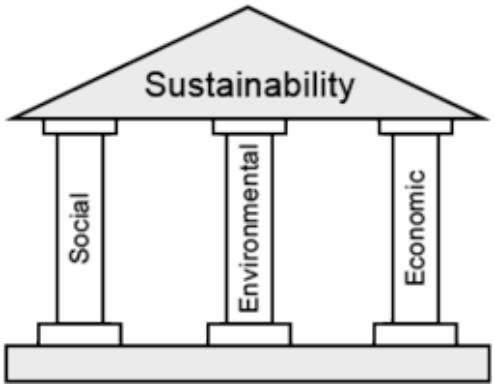
Outside of government, one of the strongest proponents of resilient cities has been the Rockefeller Foundation which launched their 100 Resilient Cities Program in response to three major trends: rapid acceleration of urbanization, impacts of climate change, and recognition of the interconnectivity of urban systems. Key goals and characteristics of a resilient city include: being aware of vulnerabilities, being flexible and adaptive in management, sharing information in an integrated way, and ensuring coordinated actions. EPA has established a memorandum of understanding (MOU) with The Rockefeller Foundation to advance systems thinking and the application of decision support tools to help cities achieve a resilient future.

In the business world the concept of resilience has grown significantly. A recent book, "Resilient by Design" by Joseph Fiksel [28] describes how businesses are grappling with the challenges of climate change and volatility in a hyper-connected, global economy. He notes that they are paying increasing attention to their organization's resilience—the capacity to survive, adapt, and flourish in the face of turbulent change. Sudden natural disasters and unforeseen supply chain disruptions are increasingly common in the new normal. Pursuing business as usual is no longer viable, and many companies are unaware of how fragile they really are. To cope with these challenges, management needs a new paradigm that takes an integrated view of the built environment, the ecosystems, and the social fabric in which their businesses operate. Fiksel argues that instead of merely reacting to disruptions, companies can become more resilient through purposeful design of their facilities, supply chains, and business practices. The book provides case studies of organizations that are designing resilience into their business processes and explains how to connect with important external systems—stakeholders, communities, infrastructure, supply chains, and natural resources—and create innovative, dynamic organizations that survive and prosper under any circumstances. For EPA, a robust and resilient economy and protection of health and the environment are all components of a sustainable society.

While sustainability often is described as the three pillars of economy, environment and human health, EPA recognizes the nested relationship of these elements as shown in figure 4. The challenge ahead is defining exactly how we can achieve sustainability given historic context and the limitations of existing rules and regulations. Today, more than ever, the creative power of science and

technology can propel humankind to new levels of global well-being.

Figure 4. Components of Sustainability



In particular, the application of technological innovation and systems thinking can help society anticipate problems and support informed decision-making. Today society needs thoughtful design of products, processes, systems and organizations, and the implementation of management strategies that effectively harness beneficial technologies and practices to avoid environmental problems before they arise. While sustainability was defined in the 1970 NEPA, the goal was also set that the U.S. "attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences" (https://www.epa.gov/nepa). A preference for prevention is evident in other environmental legislation such as the Clean Air Act air toxics regulations which set the highest priority on elimination or reduction of emissions through process changes, substitution of materials, or other modifications.

5.0 Business-Government Cooperation

The combined pressures of social, economic, and environmental impacts have inspired many business sectors to better understand and embrace the importance of sustainability. Leading executives generally accept the fact that protecting the environment reduces long term risk, builds customer support, and makes good business sense. This is why many business leaders are adopting the circular economy framework and focusing on the full life cycle of production and use.

Business and government are critical players in economic and material needs, a stable society, and building a sustainable future. The World Business Council for Sustainable Development (WBCSD) has developed an ambitious agenda to assist global industries in moving toward sustainable growth. The Council's Vision 2050 report coined the phrase "green race," and outlines a "pathway that will require fundamental changes in governance structures, economic frameworks, business and human behavior." The report argues that these changes are "necessary, feasible and offer tremendous

business opportunities for companies that turn sustainability into strategy." [29]

At the same time, business and government leaders acknowledge the complexity of coupled human and natural systems, which require flexible and adaptive polices in order to achieve sustainable and resilient outcomes. This only accentuates the need for partnership and collaboration between federal agencies and all stakeholders.

In a paper prepared for the 2010 Rio +20 Anniversary Summit (2012) "Creating the Future We Want," Hecht, Fiskel, and co-authors argued for effective collaborations, green business strategies, enlightened regulations and policies, and public support and understanding, in order to overcome the traditional adversarial gap between business and government. [30] Major advances have been made in system science, supply chain analysis, and decision support tools. For example, circular economy practices can result in greater resource efficiency, less use of hazardous chemicals, and reduction in the amount of waste and emissions produced through manufacturing activities. Effective application of scientific tools (such as green chemistry and life cycle analysis) can advance sustainable material design and reduce long-term human and environmental risks.

One example of business-government cooperation is worldwide efforts to implement the UN Sustainable Development Goals (UNSDG) adopted in 2015. (See Figure 5). The Global Reporting Initiative (GRI), the United Nations Global Compact, and the WBCSD have joined forces in mobilizing the private sector to play a key role in achieving these goals. They assert that over the next decade responsible businesses can provide an extraordinary boost in realizing the UNSDGs through innovation and investment. This demonstrates how government-business cooperation can generate benefits for society at large.

Figure 5. UN Sustainable Development Goals

7.0 The World Ahead and EPA at 50

The Environmental Protection Agency is committed to protecting human health and the environment. Since first established in 1970, the functional role of EPA has evolved to keep pace with the changing nature of environmental problems. In the 1960's there were longstanding and obvious threats to human health from air, water and land pollution. For example, in 1969, the Cuyahoga River in Cleveland Ohio famously ignited when sparks from a passing train met oil residues floating on its surface. This event brought national attention to environmental problems in the Great Lakes region and elsewhere in the country. **(**See Figure 6**)**

Figure 6. The Burning River in Cleveland


CLEVELAND PLAIN DEALER

OIL SLICK FIRE RUINS FLATS SHIPYARD

Surly Ohio Pen Rebels Fed at Gunpoint

FLAMES HIT DRY DOCKS, THREE TUGS

PRISON GETS FIRST QUIET AFTER RIOTS

1948 CASTS A VEIL OVER 'IKE TO WIN'

The EPA's first Administrator, William Ruckelshaus, noted in an interview in 2015 that in the 1960's we "had all kinds of evidence flashing across television screens every morning or every evening about rivers catching on fire, smog alerts, badly polluted waters and air all over the country. And people were reacting to that and demanding action. And they saw the action was primarily at the state level and so they were strongly encouraging the federal government to take a more major role." [31]

The many events of the 1960's spurred public attention and led to bipartisan support for the enactment of the National Environmental Policy Act (NEPA) signed by President Nixon on New Year's Day in 1970. This remarkable piece of legislation established a national goal of creating and maintaining "conditions under which humans and nature can exist in productive harmony, and fulfill the social, economic and other requirements of present and future generations of Americans." NEPA was followed by an Executive Order by President Nixon that created the Environmental Protection Agency, motivated the long-term vision to "fulfill the responsibilities of each generation as trustee of the environment for succeeding generations."

What followed in the 1970's was the passage of extensive bipartisan Congressional legislation that was concerned with single-media pollution and resulting impacts on human health. This included the passage of the 1970 Clean Air Act, the 1972 Clean Water Act, the 1973 Endangered Species Act, the 1974 Safe Drinking Water Act, the 1976 Resource Conservation and Recovery Act and the 1980 Comprehensive Environmental Response, Compensation, and Liability Act, more commonly known as the Superfund Act.

When EPA was created there was strong support for federal leadership in controlling pollutant emissions through legislation. Laws enacted later, such as the 1990 Pollution Prevention Act, aimed to reduce the sources of pollution rather than controlling emissions—a more economically efficient approach. In the Pollution Prevention Act, Congress declared it to be the national policy of the United States that "pollution should be prevented or reduced at the source whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner, whenever feasible; pollution that cannot be prevented or recycled should be treated in an environmentally safe manner whenever feasible; and disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner." The above legislation and subsequent enforcement actions provided a sound foundation for protection of the environment and human health.

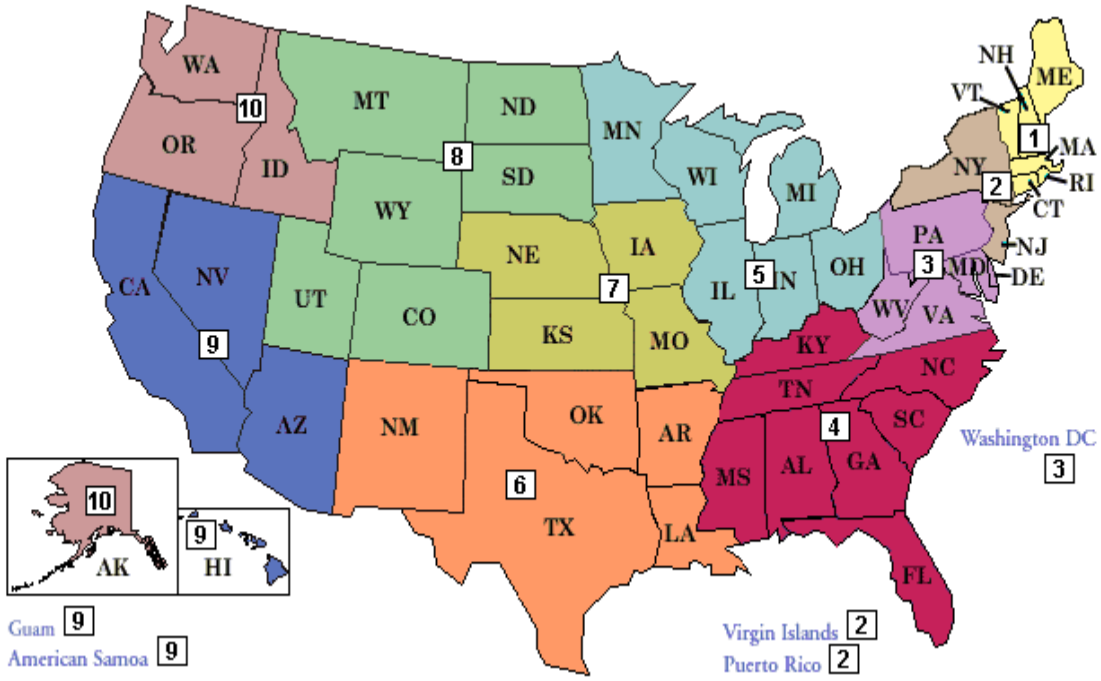
Since the 1970's EPA has evolved to effectively deal with the changing nature of environmental problems. In a paper written to celebrate EPA at 40, Hecht, Fiksel, and co-Authors outlined the steps needed to bring environmental protection into the 21st century and described the elements of sustainability science. [32] The authors noted the "multiple stressors in the environment and the need to address these stressors in an integrated manner." Today, this paper emphasizes the combined impacts of megatrends and the need for the public to fully understand the stresses on their health and the environment.

Global problems today require actions focused on building a resilient and sustainable society. Efforts must also be made to anticipate and plan for future changes. While the public and business world still may view EPA as a "regulator," EPA's role is much broader—now being recognized as a key convener of stakeholders and as a leader in science and technology innovation. The challenge ahead for EPA is to better educate the public about its expanded roles and to provide insights to planners dealing with present and future megatrends.

While EPA is often portrayed as a large, Washington, DC-based Federal Agency, it is actually composed of a relatively small headquarters and 10 regional office strategically located to cover all 50 states. (See Figure 7.) Activities in each region are driven by local legislation and pressing economic and social issues. These regions face a wide assortment of economic and environmental problems, but they all face the common challenge of achieving a resilient and sustainable future. For example, while Region 6 deals with a long period of disaster recovery in the Gulf of Mexico, its future goals must include resilient and sustainable cities. Region 9 may be facing serious potential drought and water problems, but again it must aim for a vision of a sustainable future. All the

Regions bring stakeholders together to address current and future problems. While they rely on the science and technology of the Agency's Office of Research and Development, EPA Regions are actively working to stimulate sustainability partnerships between universities and local governments, where students focus on real-world city projects as part of their coursework. Through these partnerships, students, faculty, and local Agency staff can explore the array of EPA research tools that can help cities deal with megatrends and achieve sustainability and resilience goals.

Figure 7. The ten regions of U.S. EPA



One example of EPA's role in education is the Report on the Environment (ROE), first published in 2003, which shows how the conditions of the U.S. environment and human health have been changing over time. The ROE presents the best available indicators of national trends in five theme areas: Air, Water, Land, Human Exposure and Health, and Ecological Condition. A total of 85 ROE indicators help answer 23 questions critical to EPA's mission of protecting the environment and human health. EPA updates the ROE indicators frequently to provide the latest available data. [33]

The health status of a population can be measured by a wide range of factors: birth and death rates, life expectancy, quality of life, morbidity from specific diseases, risk factors, use of ambulatory care and inpatient care, accessibility of health personnel and facilities, financing of health care, health insurance coverage, and many other factors. The ROE presents three widely accepted measures to assess trends in health status in the United States: General Mortality, Infant Mortality, and Life Expectancy.

7.0 Summary

Overcoming Global Pressures to Achieve a Healthy, Resilient and Sustainable Society

It is notable today that nearly all of the Earth's systems are undergoing natural and human-induced stresses which are outpacing national and international environmental protection efforts. This represents a major challenge for both government and business. In the decades ahead, progress must be accelerated to (1) anticipate and respond to future trends; (2) recognize the nexus of food-energy-water systems and links to environmental and social justice; (3) apply an integrated systems approach to formulation and problem solving; (4) use a suite of decision support tools to help decision makers understand the consequences of their action; (5) recognize the need for flexible environmental management and external collaboration to achieve a resilient and sustainable society and (6) create a new era of environmental management and education for the general public. These actions are critical for ensuring a strong economy. Society must transcend the traditional conflicts between business and government, and the public must view EPA at 50 to be as much an "Economic Productivity Advocate" as an "Environmental Protection Agency."

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