

Review Article

Responding to Megatrends for Resilient and Sustainable U.S. Cities

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Received: 10-05-2016

Accepted: 11-09-2016

Published: 12-22-2016

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Abstract

A megatrend is a long-term change that affects governments, societies and economies permanently over a long period of time. A number of global megatrends discussed in this paper are interrelated in impacting the economic, social and environmental well-being of cities and society today. These include population growth, increases in extreme events and natural disasters, growing environmental and health impacts due to climate change, infrastructure decline, and land use changes. These megatrends are not ranked but are inter-related and occurring at an accelerated pace causing increased pressure on the environment, the economy, and human well-being. Federal, state and business actions to address these trends must be done in a timely and integrated manner. The Environmental Protection Agency (EPA) in particular can make a difference in addressing the environmental and human health challenges of these megatrends. This paper identifies several key EPA actions for advancing a more resilient and sustainable society. These actions include (1) Anticipating future changes and adopting foresight management; (2) Applying systems thinking in problem solving; (3) Developing and using decision support tools; (4) Advancing green design and infrastructure; (5) Advancing environmental education and understanding of future threats and the links between the environment, the economy, and human well-being; and (6) Expanding stakeholder engagement and cooperation especially between business-government cooperation.

Keywords: Mega trends; Extreme Events; Resilience; Foresight Planning; Sustainable Cities

Introduction

How can federal and state governments in appropriate coordination with the business world best prepare better for the future? What are the major drivers of change? What are the tools and approaches needed to ensure a resilient and sustainable society? These are critical questions to be addressed at all levels of government and business.

A 2015 Report from the National Science Foundation (*America's Future: Environmental Research and Education for a Thriving*

Century: A 10-year Outlook) outlined future challenges and noted that “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.” [1] This is driven by the fact that the world population is expected to increase by 38%, from 6.9 billion in 2010 to 9.7 billion in 2050. Population increase will put significant pressure on water, energy, and food resources. According to the International Union for Conservation of Nature (IUCN), “By 2050, a global popu-

lation of 9 billion will increase water demands by 55 percent, energy needs by 80 percent, and food demands by 60 percent” [2].

While half of the world’s population now lives in towns and cities, by 2030 this number will increase to about 5 billion. The impact of urban growth is outlined in a chapter in the recent Intergovernmental Panel on Climate Change (IPCC) report on “Human Settlements, Infrastructure, and Spatial Planning.” The Report notes that the “speed of urbanization is unprecedented: more than half of the world population live in urban areas and each week the global urban population increases by 1.3 million.” [3] Growth of population also increases the consumption of goods which in turn requires effective production and manufacturing.

Cities are major centers for economic, social and environmental problems. They are now already facing serious problems resulting from increases in extreme weather and climate events such as extended droughts, extreme heat days and flooding which are seriously impacting human health and economic growth. It is now projected that in the decades ahead, droughts in the U.S. Southwest and Central Plains could be drier and longer than drought conditions seen in those regions during the last 1,000 years. It is also projected that rising sea levels could leave nearly 2 million U.S. homes inundated by 2100, a fate that would displace millions of people and result in property losses totaling hundreds of billions of dollars. In the decades ahead, cities and states will also face increased costs due to natural and manmade disasters. The 2015 UN Global Assessment Report on Disaster Risk Reduction predicted that disasters are expected cost global communities up to \$300 billion annually in the coming decades [4]. Cities must also deal with increasing health, economic and social problems, especially in disadvantaged communities. The link of social issues to sustainability has been strongly emphasized by a 2016 NAS report on “Pathways to Sustainable Communities.” This new Report also emphasizes the important of dealing with megatrends. Looking ahead, the Report makes one very important recommendation for dealing with the changing nature of problems today: “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.”

Many US federal agencies are deeply involved in working with cities and states. A White House initiative on “Smart Cities” (launched in 2015) aims to enhance the federal cooperation to help cities deal with present and future problems. For EPA, a protector of human health and the environment, the goal of building a sustainable and healthy community is a number one priority. As described in this paper the EPA goal of “making a visible difference in communities” is a major challenge to achieve a more resilient and sustainable future and address the growing pace and number of megatrends.

Mega Trends Impacting Society

A megatrend is a long-term change that affects governments, societies and economies permanently over a long period of time. A selection of critical megatrends impacting cities and society is shown in Table 1. These megatrends are not ranked but are inter-related and occurring at an accelerated pace causing increased pressure on the environment, the economy, and human well-being. These were selected because of their national and international impact.

These global trends affect both developed and developing countries. The largest population increase is projected to occur in Asia, particularly in China, India and Southeast Asia, accounting for about 60% and more of the world’s population by 2050. For the US we expect an increase of more than 400 million by 2050. Related to population growth is consumption of food, energy, water and natural resources. Past population growth over the past 50 years has already reduced the earth’s ecosystems by about 60%. In looking ahead, consumption of resources will grow with developed countries consuming around 80% of the resources while developing and underdeveloped countries consuming 20% of earth resources. Focus in this paper is on the impact of megatrends on US cities which may vary depending on both population and economic growth, social well being and geographic location.

Two critical management issues have been identified for dealing with these trends. The first, identified by the UN Global Environmental Outlook (GEO) 2016 report is that the “environmental change sweeping the world is occurring at a faster pace than previously thought, making it imperative that governments act now to reverse the damage being done to the planet.” [14] The second identified by the financial company KPMG, in their 2030 analysis of megatrends notes that the combined pressures of population growth, economic growth and climate change are all interrelated in placing increased stress on essential natural resources (including water, food, arable land and energy) [15]. Hence it is crucial to advance a systems approach to environmental management and to do so in a timely manner.

While these trends affect all of society, cities are critical focal points for their impact. Today cities are already facing serious health related problems resulting from climate change. Climate change is not the only cause of air and water pollution, but it does exacerbate existing problems. Looking ahead, 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. At the same, summer extreme heat can be 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. One model projected an increase, from a 1990 baseline for more

Trend	Data
Population Growth, Increase in Urban Communities and Growing Consumption Patterns	Estimate of 9 billion by 2030 with increased resource demands including 50% more energy, 40% more water and 35% more food. In 2008, for the first time in human history, more people lived in urban areas than in rural areas. The pace of urbanization continues to increase. More than 80 percent of the U.S. population lives in urban areas [5]. Globally, urban populations are expected to double by 2050, to 6.2 billion [6].
Increase in Extreme Events and Natural Disaster	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 [7]. This 10-year period accentuates a dramatic increase in the costs of natural disasters over the past 50 years [8]. The US experienced more disasters over this period than any other country except China. A cost of \$443 billion in damages (close to a third of total losses) winning the dubious prize for the most disaster damages [9]. The UN Global Assessment Report predicts that disasters are expected to cost the global community up to \$300 billion annually in the coming decades.
Impacts of Climate Change	Drought in the western US over the past decade has 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. At the same time intense rain fall will continue to hit the Northeast more frequently. Sea level rise threatens coastal communities. Coastal counties comprise only 17 percent of the nation's land area but contain 52 percent of the U.S. population which keeps on growing [10]. The insured value of property along the Atlantic and Gulf coasts rose by nearly 50 percent from 2004 to 2012, from \$7.2 trillion to \$10.6 trillion [11].

Human Vulnerability and Impacts on Disadvantaged Communities	<p>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]. In the US poverty rates have been growing, savings rates have been declining, and disasters disproportionately affecting the poor. Economically disadvantaged individuals and communities are more vulnerable to natural hazards.</p>
Infrastructure Needs	<p>By 2030 approximately 75% of U.S. infrastructure will either need to be renovated or be built from scratch. (“Rockefeller Foundation: Build America”.)</p> <p>Investment needs for buried drinking water infrastructure total more than \$1 trillion nationwide over the next 25 years, assuming pipes are replaced at the end of their service lives and systems are expanded to serve growing populations.</p>
Land Use Change and Growing Eco Footprint	<p>Although the US is one of the richest nations in the world in terms of natural capital, it is running an ecological deficit. U.S. citizens demand twice the renewable natural resources and services that are available within our nation’s borders [13].</p>

Table 1. Megatrends

than 200 American cities, of more than an additional 11,000 deaths during the summer in 2030 and more than an additional 27,000 deaths during the summer in 2100.

On the social side climate change is also predicted to have a large health impact on vulnerable populations in low income and disadvantaged communities. The ability of cities to respond to disadvantaged communities is a critical challenge especially in regard to future trends. EPA has a lead role in helping disadvantaged communities and has prepared a 2020 Environmental Justice Action Plan to help disadvantaged communities achieve a healthier, cleaner and more sustainable society. The Plan was developed based on stakeholder input

representing the present and future environmental challenges facing American communities today. The Plan emphasizes the importance of infrastructural planning and design and the application of tools and approaches for building resilient and sustainable cities for all economic elements of society [16].

World attention on these megatrends is clearly illustrated by the 2015 adoption of the UN Sustainable Development Goals (SDGs). The 17 goals have 169 specific targets and 230 individual indicators to monitor the goals and actions [17]. The link between these goals and the megatrends are shown in Table 2.

MegaTrend	Related UNSDGs
Population Growth, Communities and Consumption	<p>Goal 1. End poverty in all its forms everywhere</p> <p>Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture</p> <p>Goal 6: Ensure access to water and sanitation for all</p>
Increase in Extreme Events and Natural Disaster	<p>Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation</p> <p>Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable</p>
Climate change	<p>Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all</p> <p>Goal 13. Take urgent action to combat climate change and its impacts</p>
Human Vulnerability and Impacts on Disadvantaged Communities	<p>Goal 3. Ensure healthy lives and promote well-being for all at all ages</p> <p>Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all</p> <p>Goal 5. Achieve gender equality and empower all women and girls.</p> <p>Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all</p> <p>Goal 10. Reduce inequality within and among countries.</p> <p>Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels</p>
Infrastructure Change	<p>Goal 6. Ensure availability and sustainable management of water and sanitation for all</p>
Land use change and growing eco footprint:	<p>Goal 12. Ensure sustainable consumption and production patterns</p> <p>Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development</p> <p>Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss</p>

Table 2

In terms of future actions discussed in this paper, it is encouraging to note that joint efforts are underway by both government and business to achieve the UNSG Goals. For example, the Global Reporting Initiative (GRI), the United Nations Global Compact and the World Business Council for Sustainable Development (WBCSD) have joined forces to mobilize the private sector as a key player in achieving these goals. They have asserted that over the next decade responsible businesses can provide an extraordinary boost in realizing the UNSDGs through innovation and investment. This government-business cooperation on achieving the UNSDGs provides a good model of how government and business can cooperate on achieving a resilient and sustainable society.

Resilient and Sustainable Cities

The concept of resiliency is now a key element of present and future planning. Resilience is defined as the ability to recover from setbacks, adapt well to change, and keep going in the face of adversity. It is a critical aspect of community sustainability.

US Public attention on resilience was enhanced by Super Storm Sandy (2012) which affected 24 states, including the entire eastern seaboard from Florida to Maine and west across the Appalachian Mountains to Michigan and Wisconsin. Damage was especially severe in New Jersey and New York. Overall damage in the US amounted to \$71.4 billion. Super Storm Sandy was one example of the growing frequency of natural and human-induced disasters which impact cities across the US. The need for governments and communities to become more resilient was also clearly evident.

Outside of government, one of the strongest proponents of resilient cities has been the Rockefeller Foundation which launched their 100 Resilient Cities Program reflecting three major trends: rapid acceleration of urbanization, impacts of climate change and recognition of the interconnectivity of all systems. Key goals and characteristics of a resilient city are being aware of vulnerabilities, being flexible and adaptive in management, sharing information in an integrated way and ensuring coordinated actions. EPA has 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 city.

Since Super Storm Sandy and based on several Executive Orders, federal agencies are strongly committed to working together to advance resilient cities. An agreement between the Department of Homeland Security (DHS), Federal Emergency Management Agency (FEMA), and the EPA is focused on:

- Coordinate activities between EPA's sustainable communities, smart growth, environmental, and community technical assistance programs and FEMA's disaster recovery planning and hazard mitigation programs.
- Provide lessons learned for EPA, FEMA, and other federal agencies that can be used to build a stronger federal framework for mitigation planning as well as pre- and post-disaster

recovery planning and operations.

- Provide a collaborative framework for policy work related to both hazard mitigation planning and climate change adaptation to create more resilient communities.

EPA has also introduced 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." A series of tools to achieve resiliency has also been developed [18].

The concepts of resilience and sustainability are strongly linked. In practice sustainable development is an integrated approach for dealing with social, environmental and economic processes which meets the needs of the present without compromising the ability of future generations to meet their own needs. The challenge ahead is defining exactly how we can achieve a sustainable society given current historic context and the limitations of existing rules and regulations.

Translating the high level goals of sustainability into practice raises a number of practical questions such as what kind of policies, strategies and practices, including science and technology are needed to advance sustainability. It is here we turn our attention to present and future actions for the EPA and cities to ensure a secure resilient and sustainable society.

EPA at 50: Enhancing Future Planning

While EPA's classic role is to protect human health and the environment, its functional role has evolved to reflect the changing nature of the environmental problems we face. 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 innovator. The challenge ahead for EPA is now to be a foresight planner dealing with present and future megatrends.

The importance of dealing with the future trends is not new and was recognized by EPA's external advisory groups and the National Academy of Sciences (NAS) as early as 1995 when the Agency's Advisory Board, in their report "Beyond the Horizon" urged EPA to "Begin to anticipate future environmental problems, and then take steps to avoid them, not just respond to them after the fact" [19].

This report noted that "the basic approach to environmental protection has been for the most part reactive." Laws and regulations were written largely in response to problems that already posed serious threats to human health and ecology. The report was timely in noting that "thinking about the future is more important today than ever before because ever-faster change is shrinking the distance between the present and the future." Key recommendations in this 1995 Report were:

- *As much attention should be given to avoiding future environmental problems as to controlling current ones.*

- *EPA should incorporate futures research and analysis into all of its programs and activities, particularly strategic planning and budgeting, and then be prepared to act-in conjunction with other public and private-sector organizations-on the basis of that information.*

- *As an essential part of its futures capabilities, EPA should establish an early-warning system to identify potential future environmental risks. Working with other agencies and organizations as appropriate, EPA should establish a look-out panel made up of individuals from inside and outside government-to provide the Agency, and the nation, with an early warning of environmental issues that may emerge in the future.*

These proposed actions were later supported by a second advisory group, the National Advisory Council on Environmental Technology & Policy (NACEPT) which in a 2002 report, "The Environmental Future" urged EPA to "Encourage environmental foresight efforts in offices and programs throughout the Agency... and Incorporate futures analysis into Agency strategic planning."

Ten years later in 2012 the NACEPT advised the EPA to "Develop an environmental scanning system and targeted foresight studies to identify emerging environmental threats and to highlight emerging ideas and technologies that support sustainability."

And in 2012 a study from the NAS "Science for Environmental Protection: The Road Ahead" identified a number of trends for EPA to consider including population growth, chemical exposure and human health exposure. The NAS Report noted that "EPA's future success will depend on its ability to address long standing environmental problems, its ability to recognize and respond to emerging challenges, its ability to link broader problem characterizations with solutions and its capacity to meet the scientific needs of policy makers and the American people" [20].

A more recent 2014 NAS Report "Sustainability Concepts in Decision-Making: Tools and Approaches for the US EPA" also noted that, "The ability to anticipate, assess, and manage challenges is at the heart of sustainability practices and therefore plays a major role in addressing new issues and evaluating strategies that can minimize potentially deleterious effects" [21].

Taking action on future planning has been slow in coming but building on all of the above the current EPA Administrator, Gina McCarthy, in 2015 stated that "envisioning and responding to future problems was a critical need." It is here that EPA science is crucial.

Science in EPA is a key driver of technical and social change and the Office of Research and Development (ORD) pays particular attention to the development of science needed to address long term trends. In preparing its research strategies for the period 2016 to 2019, ORD did look ahead and turned to its Science Advisory Board (SAB) and the Board on Scientific Counselors (BOSC) to get their assessment on "what are the

SAB/BOSC perspectives overall on the proposed research directions to address environmental issues of 2020 and beyond? [22]

In response, the SAB/BOSC made several important recommendations and observations. They noted that ORD has made significant progress in planning its research in a framework that anticipated the major environmental challenges confronting the United States. They urged that

ORD should explicitly address environmental issues of 2020 and beyond. They recommended specific areas of focus to "provide a more explicit description of the approach used to identify research necessary to anticipate emerging environmental issues." Specifically, they asked ORD to better articulate "early risk detection efforts at multiple geographic and temporal scales. Early detection requires ongoing consultation with advisors and a wide spectrum of partners, stakeholders and experts to identify emerging problems and research needs" [23].

The SAB also noted that ORD should recognize that many anticipated issues will arise as a direct result of the tensions between growth (e.g., population, consumption, economic) and finite resources (e.g., natural resources, biodiversity.) They suggested that ORD consider a combination of stressors, drivers, and impacts. Examples of these include (1) climate change, (2) habitat loss, (3) introduced/invasive species, (4) eutrophication, (5) chemical contamination, (6) evolving demographics and social systems, (7) technologies affecting the extraction and use of energy, and (8) continued transformations of land use and land cover.

As noted above the future success of dealing with megatrends is also to recognize how integrated are the actions needed to deal with stresses on air, water, and land issues. A systems approach to dealing with present and future issues is clearly needed. In fact the concept of the nexus of land-water and food issues is now widespread especially at the city level. For example, in 2014, the U.S. Chamber of Commerce Foundation (USCCF) conducted research to better understand the interdependencies between energy, water, and food [24]. While the main thrust of the research was aimed at the private sector, the conclusions equally apply to federal and state governments. The ultimate goal is to make operations resilient to energy, water and food shortages. The research found that systematically addressing resiliency to nexus challenges requires the following steps, which are relevant to EPA actions:

1. UNDERSTANDING the interconnected nature of the nexus.
2. SURVEYING and DATA COLLECTING to understand the resources on which a company depends.
3. ASSESSING RISKS and OPPORTUNITIES to see how a corporation's consumption of resources can impact business operations.
4. IMPLEMENTING technologies and programs to mitigate risks.

- 5. COLLABORATING with stakeholders to address shared risks.
- 6. LEADING the charge to address nexus challenges through engaging the business community.

All of the above are aimed at anticipatory actions addressed in a systematic way with full stakeholder engagement. Critical next steps are described below.

Next Steps to Achieve Resilient and Sustainable Society

EPA is strongly committed to working with other federal agencies, states and communities to ensure a resilient and sustainable society. Within EPA’s current Strategic Plan, the “Making a Visible Difference in Communities” initiative has program offices, regional offices and communities acting in concert to address significant community problems.

The US is divided into 10 EPA regions shown in Figure 1. In each area extensive activities are ongoing in reaching out to local communities, universities, businesses, and the general public. It is at the city and community levels that major impacts are felt and where integrated and system thinking is crucial.

EPA Regions

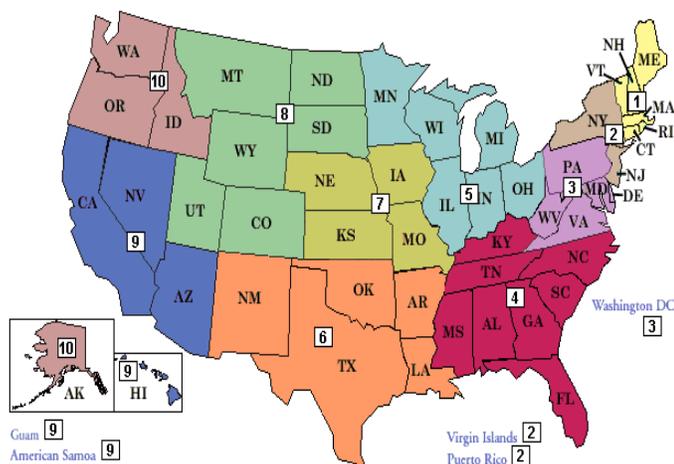


Figure 1

As mentioned earlier, one of the key challenges all cities face is dealing with climate change. A recent Report on “States at Risk: America’s Preparedness Report Card” quantifies the climate threats for each of the 50 states and assesses the level of action states have taken to deal with those risks. Every state receives a conventional letter grade to illustrate its climate change preparedness [25].

The report covers 5 specific threats: extreme heat, drought, wildfires, inland flooding, and coastal flooding. Different states have different levels of climate risks, and some are better prepared than others. Overall, the analysis found that states across the country are largely unprepared to face the considerable and significantly increasing threat levels posed by the future changes in these 5 climate threats. Overall, 10 states received an A for their climate change preparedness: California, Mas-

sachusetts, New York, Pennsylvania, Connecticut, Delaware, North Carolina, Maryland, Washington and Virginia. Ten states earned an F: Texas, Nevada, Missouri, Mississippi, Arkansas, Alabama, Ohio, Montana, South Dakota and Kentucky [26].

Given the above, a challenge for EPA and all agencies is to improve the ability of states to respond to climate change, and look beyond single media operations which is still apparent to many regional and state groups. For example, on the issue of water and energy, the National Council on State Legislature (NCSL) has recognized that State legislatures and natural resource managers have traditionally addressed water and energy as two separate issues. 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 [27].

In planning future operations related to water, energy or ecosystem services, and in dealing with climate change, the engagement of State lawmakers and constituents will be critical given their responsibility in formulating policy, convening stakeholders, facilitating negotiations, and ratifying reached agreements.

Building on current collaborations, several steps as outlined in Figure 2 are needed to deal with mega trends and achieve a resilient and sustainable society.

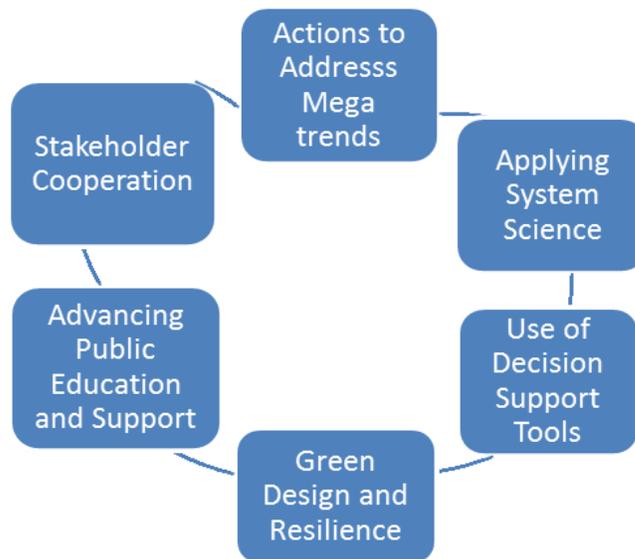


Figure 2

Foresight Planning

As discussed above the ability to anticipate and prepare for the future is not a new concept for EPA. Today, however, foresight planning is a major priority and needs to become a management focus for the future. Government and business actions today must be built more on anticipatory governance rather than “events driving actions.” The term anticipatory governance is based on the work of Leon Fuerth and Evan M. H. Faber and their “Project on Forward Engagement” (Fuerth,

2013.) Fuerth has argued that rather than relying on crisis management, anticipatory governance is needed to link analysis and policy making that gets ahead of events. He notes that “If the United States is to remain a well-functioning republic and a prosperous nation, the government cannot rely indefinitely on crisis management, no matter how adroit. We must get ahead of events or we risk being overtaken by them. In short, we must improve our management systems to meet today’s accelerating and complex challenges” [28].

This vision was reinforced by a recent internal EPA study on foresight planning which affirmed that the future success of EPA depends on its ability to be creative in addressing future problems. One key future action is to conduct scenario planning, working across all EPA programs and regions and with cities and state and business leaders. At the same time, future success depends on ability to address complex issues in a more integrated manner.

Promote Systems Thinking in Problem Solving

A key measure of success is for EPA and other agencies to overcome the constraint of their long term media-centric statutory authorities. The mentioned NSF 2015 Report on America’s Future emphasizes that “the environment is a network of complex socio-environmental systems, and stresses the need to integrate our understanding of biophysical processes, social processes and engineered systems.”

It is no longer effective to just think in terms of single media (such as just clean air or clean water) actions since air and water are intimately linked together. Breaking out of silos was a key recommendation of the 2013 NAS report “Sustainability for the Nation,” which emphasized the need for integrated decision making and identified 4 priority problems: nexus of energy-food and water; and the need to address diverse and healthy communities, enhance resilience of communities to extreme events and promote human health and wellbeing.

In recent years, ORD has worked toward facilitating systems thinking by developing tools and methods for integrated sustainability assessment. “Systems thinking” is a holistic approach for understanding the dynamic interactions among complex economic, environmental, and social systems and for evaluating the potential consequences of interventions, such as new policies, technologies, and new operating practices. EPA cross-cutting strategy “Working toward a Sustainable Future” states that the Agency should “use systems-based approaches that account for linkages between different environmental systems.” The potential benefits for decision makers is to understand the full range of potential outcomes, including unintended consequences. EPA Regions are beginning to apply system approaches to enhance effective decision making. One study in Region 1 was aimed at reducing the flow of nitrogen into Narragansett Bay. This was an economic and social challenge for government and business. Region 1 and EPA ORD worked together to apply a systems model which allowed users to run a variety of different scenarios that simulate the impacts of

specific interventions on the economic, environmental, and social sectors of the watershed. This project was also a perfect example of stakeholder engagement in decision-making.

Use of Decision Support Tools

A key step toward future planning is assessing consequences of proposed action. EPA has a long history of developing and using a wide variety of “tools” (for example cost-benefit analysis) to support decision-making about environmental policies, technologies, and practices. Historically, such decisions were made with a narrow focus on specific outcomes, such as reduction in human health risk from a specific pollutant or source category.

The use of a variety of tools is a critical element of EPA’s aim to “Make a Visible Difference in Communities” which is a strategic priority for EPA to find new ways to assist communities that are disproportionately impacted by pollution, economic distress and related challenges. In 2015, EPA identified more than 50 environmentally overburdened, underserved, and economically distressed communities for more focused and coordinated action. Applying a variety of tools, EPA is working with local, state and other federal partners to help communities improve environmental conditions, economic opportunity and quality of life.

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 [29]. EPA also now 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 sustainable approaches.

In recognizing the pressures of mega trends, EPA has developed an extensive set of tools to help decision makers better understand the impact of proposed actions. 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 scale. Using Enviro Atlas, users can access, view, and analyze diverse information to better understand the potential impacts of various decisions.

In support of Environmental Resilience as defined above EPA has also developed extensive tools to help build a resilient society. ORD has developed an “Inventory of EPA’s Tools for Enhancing Community Resilience to Disasters” which reviews and summarizes many of the tools EPA has available for federal partners, states and local governments, utilities, communities, and individuals to help build resiliency to disasters.

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.

These and many others can help communities better prepare for the future which will be affected by numerous mega trends resulting from climate change, population growth, and increase in extreme weather events. A sample of EPA decision support tools that can help communities deal with emerging trends is shown in Table 3. EPA has hundreds of such tools and the challenge ahead is work to expand their application to cities and communities and demonstrate the value of using them.

Green Design and Resilience:

Going beyond the traditional regulatory focus of EPA is the application of green infrastructure and building design. It is here that creative architecture, adoption of building codes and applying ecosystem services can help communities. Many cities are adopting the International Green Construction Code, the first model code to include sustainability measures for an entire construction project and its site — from design through construction, certificate of occupancy and beyond. The 2012 code is expected to make buildings more efficient, reduce waste, and have a positive impact on health, safety and community welfare [30]. Another example is the new Federal Flood Risk Management Standard (FFRMS) that requires all future federal investments in floodplains (and areas affecting them) to meet a new, higher level of resilience. Expanding the FFRMS approach to other hazards and emphasizing the broader adoption of code-plus standards in our communities will allow us to design greater resilience into our built environment as we look ahead to more-dynamic risks in the future.

A joint program between the Department of Defense and EPA on Net Zero which aims to help cities conserve water, reduce energy use, and eliminate solid waste can deal with megatrends by improving the environment, saving money, and helping communities become more sustainable and resilient. The goals of Net Zero are consuming only as much energy as produced, achieving a sustainable balance between water availability and demand, and eliminating solid waste sent to landfills [31].

EPA, Department of Agriculture, Department of Defense, Department of Energy, Department of Housing and Urban Development, Department of the Interior, and Department of Transportation are working together on “Green Infrastructure Collaboration.” The goal of this is to leverage joint efforts to

publicize the multiple community benefits of green infrastructure, build and share knowledge around emerging green infrastructure technologies and policy issues, and facilitate shared inquiry into the best ways to encourage adoption of green infrastructure technologies at the community level.

Advancing Environmental Education:

The National Environmental Education Act of 1990 requires EPA to provide national leadership to increase environmental literacy. EPA established the Office of Environmental Education to implement this program. In looking ahead the challenge is to increase environmental literacy in universities and communities on emerging trends and approaches for problem solving. It is especially important that society understands the growing pressures on the environment and what federal actions are needed. It is here that EPA interaction with universities and local communities can be especially helpful in training and inspiring the next generation. 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 classwork. Through these partnerships, students, professors, and local government staff can explore the array of ORD research tools that can help cities deal with megatrends and achieve sustainability and climate resilience goals.

EPA’s Report on the Environment is also a useful means to share information with the general public. A crucial challenge today is for all regions to identify their key challenges and work with communities to plan effective responses. Long-term risk must be better understood by all communities.

Federal and Stakeholder and Business Collaboration:

Addressing problems today and in the future demands more partnership and collaboration between federal agencies and all stakeholders. As mentioned above, this has been reinforced by the recent PCAST Report. One successful example of ongoing federal cooperation is the Partnership for Sustainable Communities between EPA, Department of Housing and Urban Development (HUD), and the Department of Transportation (DOT) to promote sustainable communities. In 2009 the three agencies agreed to work together to achieve critical goals for urban development. The agencies also worked together on tools and metrics to benchmark existing conditions, measure progress toward achieving community visions, and increase accountability. This joint effort by HUD, DOT, and EPA also aims to remove barriers that prevent coordinated housing, transportation, and environmental protection investments.

In looking ahead, business–government collaboration is going to be crucial in dealing with the nexus of food, energy and water. In a paper prepared for the 2010 Rio +20 Anniversary Summit, authors argued that in “Creating the Future We Want,” effective collaborations, green business strategies, enlightened regulations and policies, and public support and understanding were clearly needed [32]. The days of conflict between business and government must come to an end.

Mega Trend	Selected EPA Tools and Approaches
<p>Population Growth, Increase in Urban Communities and Consumption Patterns</p>	<p>Enviro Atlas https://www.epa.gov/enviroatlas. Provides interactive tools and resources for exploring the benefits people receive from nature or "ecosystem goods and services".</p> <p>Community-Focused Exposure and Risk Screening Tool (C-FERST) and Tribal focused Environmental Risk and Sustainability Tool (T-FERST) https://www.epa.gov/healthresearch/community-focused-exposure-and-risk-screening-tool-c-ferst. Information to help communities and tribes understand potential environmental public health issues in their communities. They also provide information about how other communities have managed similar issues, and recommendations from EPA and other federal agencies on reducing exposures and risks.</p>
<p>Increase in Extreme Events and Natural Disasters</p>	<p>Computer-Aided Management of Emergency Operations (CAMEO) https://www.epa.gov/cameo. CAMEO is a system of software applications used to plan for and respond to chemical emergencies.</p> <p>Storm Water Management (SWMM) Determines which low-impact development and green infrastructure projects are effective in managing stormwater and combined sewer overflows.</p> <p>I-WASTE. Provide access to technical information, regulations, and guidance on waste characterization, treatment, and disposal options, and how to incorporate waste management into planning, response and disaster recovery activities.</p> <p>Automated geospatial Watershed Assessment Tool (AGWA): Identify problem areas in watersheds where mitigation measures can be focused and provide decision support for watershed planning efforts based on variable scenarios and conditions prior to or following an event.</p> <p>National Stormwater Calculator. This tool helps designers and land use planner estimates for the amount of rainwater and frequency of runoff anywhere in the United States. https://www.epa.gov/water-research/national-stormwater-calculator.</p>
	<p>CREAT: The climate change risk assessment tool allows water utilities to evaluate potential impacts of climate change</p>

<p>Impacts of Climate Change</p>	<p>Climate Resilience Tool Kit provides businesses and communities information on responding to the challenges of our changing climate.</p> <p>http://toolkit.climate.gov/.</p> <p>BASINS Climate Assessment Tool (CAT) provides a flexible set of capabilities for exploring the potential effects of climate change on streamflow and water quality using different watershed models.</p>
<p>Human Vulnerability and Impacts on Disadvantaged Communities</p>	<p>EJSCREEN https://www.epa.gov/ejscreen. Allows users to access high-resolution environmental and demographic information for locations in the United States, and compare their selected locations to the rest of the state, EPA region, or the nation.</p> <p>Health Impact Assessment (HIA): determines the potential effects of a proposed decision on the health of a population and the distribution of those effects within the population.</p>
<p>Infrastructure Needs</p>	<p>Green Infrastructure Wizard (GIWIZ) Green infrastructure uses natural landscapes to manage water and provide environmental and community benefits. GIWiz provides access to tools and resources that can support and promote water management and community planning decisions.</p> <p>https://www.epa.gov/communityhealth/green-infrastructure-wizard.</p> <p>Storm Water Management Model (SWMM) is used for planning, analysis and design related to stormwater runoff, combined and sanitary sewers, and other drainage systems in urban areas. There are many applications for drainage systems in non-urban areas as well. https://www.epa.gov/water-research/storm-water-management-model-swmm.</p>
<p>Land Use Change and Growing Eco Footprint</p>	<p>Report on the Environment is an interactive resource that shows how the condition of the environment and human health in the United States is changing over time. Presents the best available indicators of national trends in Air, Water, Land, Human Exposure and Health, and Ecological Condition.</p> <p>https://cfpub.epa.gov/roe/.</p>

	<p>Net Zero strategies, approaches, and technologies help communities reduce energy, water and material waste. All Net Zero projects are geared toward helping communities become more sustainable and resilient with an emphasis on taking a systems approach. https://www.epa.gov/water-research/net-zero-projects.</p>
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Table 3

Major advances in system science, supply chain analysis, application and use of decision support tools give us valuable tools for both business and government in dealing with future issues. For example, business operation on the principle of a circular economy can significantly result in fewer resources used, reduction in hazardous chemicals and decrease 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 use to better understand and reduce long term risk.

Summary

Today it is abundantly clear that we must be out front on issues and aim to build a resilient and sustainable society. After 40 plus years of debate on climate change, we are today adapting to rather than preventing climate change. Lessons learned in dealing with past environmental problems, especially climate change, make it abundantly clear that more anticipatory and timely actions are needed in dealing with problems today.

Growing trends in all megatrends including population growth, urban development, resource use, consumption and extreme events will strongly impact our economic, social and environmental wellbeing. It is now abundantly clear that future problems need to be addressed in a more timely and integrated manner. Science is the foundation for change and the use of systems analysis and use of decision support tools can help decision makers understand the consequences and tradeoffs and potential benefits of proposed actions. Overcoming long standing conflict to enhance business-government collaboration is also a step needed to achieve more sustainable outcomes.

In the coming decades, EPA's mission must operate to ensure long-term environmental quality and sustainability. It is unfortunate that government and business often engage with serious problems only after a disaster or tipping point has occurred. While we have long debated how to respond to climate change, it took Superstorm Sandy to propel actions on resilience and climate adaptation. Events like this can drive action but can also cost billions of dollars. We do not want a world where we have to repeatedly rebuild our institutions and infrastructure because of environmental or economic disasters.

Past history and present stresses suggest that government operations must:

- Acknowledge, respond and anticipate mega-trends
- Promote cross-program integration and create effective collaborations and partnerships.
- Promote innovation in science and technology and advance application of decision-support tools, and
- Enhance public understanding and support.

Only in this way can we be assured of healthy, safe and resilient communities with high quality of life for all residents.

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