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Research Article

EPA Leadership on Science, Innovation, and Decision Support Tools for Addressing Current and Future Challenges

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Abstract

When the U.S. Environmental Protection Agency (EPA) was established nearly 50 years ago, the nation faced serious threats to its air, land, and water, which in turn impacted human health. These threats were effectively addressed by the creation of EPA (in 1970) and many subsequent landmark environmental legislations which in turn significantly reduced threats to the Nation's environment and public health. A key element of historic legislation is research aimed at dealing with current and future problems. Today we face national and global challenges that go beyond classic media-specific (air, land, water) environmental legislation and require an integrated paradigm of action and engagement based on (1) innovation based on science and technology, (2) stakeholder engagement and collaboration, and (3) public education and support. This three-pronged approach recognizes that current environmental problems, include social as well as physical and environmental factors, are best addressed through collaborative problem solving, the application of innovation in science and technology, and multiple stakeholder engagement.

To achieve that goal, EPA's Office of Research and Development (ORD) is working directly with states and local communities to develop and apply a suite of accessible decision support tools (DST) that aim to improve environmental conditions, protect human health, enhance economic opportunity, and advance a resilient and sustainability society. This paper showcases joint EPA and state actions to develop tools and approaches that not only meet current environmental and public health challenges, but do so in a way that advances sustainable, healthy, and resilient communities well into the future. EPA's future plans should build on current work but aim to effectively respond to growing external pressures. Growing pressures from megatrends are a major challenge for the new Administration and for cities and states across the country. The recent hurricanes hitting Texas and the Gulf Coast, part of the increase in extreme weather events, make it clear that building resilient infrastructure is a crucial step to sustainability.

Keywords: Resilience; Sustainability; Smart cities; Decision Support Tools

Introduction

"Once you stop learning, you start dying." Albert Einstein

Today the world faces daunting social, economic, and environmental challenges resulting from urban population growth, changes in air and water quality, biodiversity loss, depletion of natural resources, impacts of climate change, increases in extreme weather events, and the often compounding interactions of multiples of these stressors. Collectively, these challenges are often referred to as "megatrends" for their multi-system complexities and large, even global, scales. [1] Such challenges go beyond classic legislation focused on single media actions like clean air or clean water. As noted in a 2017 report from the National Intelligence Council (NIC) nearly all of the earth's systems are undergoing natural and human-induced stresses that are "outpacing national and international environmental protection efforts [2]." Meeting these challenges is thus a critical challenge to advancing economic growth and international stability.

Given the growing economic impacts of emerging and projected megatrends, leaders from across the governmental, nongovernmental, and business sectors recognize the need to advance solutions that not only address immediate environmental challenges, but also achieve resilient and sustainable outcomes. In this context, resilience is defined as the ability to anticipate, prepare for, adapt, and recover from changing conditions, especially from natural disasters and extreme weather events as is most evident on coastal communities.

States and federal governments are not alone in developing resilient systems. Actions on resilience are being significantly advanced by businesses and non-government organizations such as the Rockefeller Foundation 100 Resilient Cities program. 100 Resilient Cities, launched in 2013, sets an ambitious goal of helping cities worldwide build resilience as a way to meet the growing social, economic, and physical challenges of the 21st century. EPA responded to their call for "Platform Partners" and signed an MOU with Rockefeller to become the first Federal Agency to become a Partner (2014.) EPA working with the Rockefeller Foundation gives participants easy access to the Agency's decision support tools and best management practices. Specific examples of tools being used to advance community resiliency are also discussed in the section on resilience.

The concept of sustainability dates back to the early 1970's when EPA was first created. Although the word sustainability was not used in the National Environmental Policy Act (NEPA), the concept was clearly a guiding principle in its stated overarching goals "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."

Twenty years later, the notion of sustainability was defined in the context of a societal value by the delegates of the first World Summit on Sustainability, held in Rio in 1992. A sustainable society was defined as "one that can persist over generations, one that is far-seeing enough, flexible enough and wise enough not to undermine either its physical or its social system of support [3]." For EPA sustainability as defined on web page is "isn't part of our work – it's a guiding influence for all of our work." Outside of government, sustainability is being embraced by the business world as an important, bottom-line metric for success. For that corporate world, sustainability has become the "mother lode" for driving organizational and technological innovation; many international firms now realize "there is no alternative to sustainable development [4]."

Given growing megatrends and their impacts on society, how can federal and local governments and the business world align to build a resilient and sustainable society? It is the combined efforts of science, technology, innovation, and stakeholder collaboration that are essential to protect current conditions and advance society to new levels of stable, ongoing well-being.

Toward this goal, EPA plays a critical role. For nearly 50 years, the Agency has learned of the need for expanded stakeholder collaboration and application of science and technology to address the wide range of environmental challenges. Over time, EPA has built on its classic role as a regulator to facilitating the development and production of safe and sustainable products, processes, and practices. Toward this goal, EPA researchers, engineers, and modelers are developing the decision support tools and other resources needed to reduce humanity's global footprint and decouple economic growth from adverse environmental impacts.

EPA evolution and success serves as a reminder of Albert Einstein's statement that to stop learning is to begin the process of dying.

This paper discusses a suite of EPA activities in partnership with states and communities showcasing the use of science, innovative technologies, and decision support tools to effectively plan for a brighter, healthier, more prosperous future. The collective integration of these activities is what we call the "innovation cycle for resilience and sustainability." In the discussion that follows, we showcase these actions in three critical areas: (1) developing community resilience; (2) advancing health and wellbeing, and (3) sustaining the benefits of ecosystems.

Innovation Cycle for Resilience and Sustainability

The four elements of the innovation cycle shown in Figure 1 are:

- 1) Stakeholder Engagement - engaging stakeholders to understand their needs, constraints, and priorities;

2) Systems thinking - advancing sustainability science and systems thinking to enable integrated problem-solving;

3) Transdisciplinary Collaboration - encouraging transdisciplinary collaboration among government, business, and non-governmental organizations to design comprehensive approaches; and

4) Decision Support - developing decision support tools to help policy and decision makers implement sustainable and resilient solutions.

The engagement of all stakeholders is critical in building consensus on action and encouraging support across political, geographic, socioeconomic, and cultural groups. EPA has extensive programs and has cultivated numerous partnerships with states, communities, and tribal leaders. Those partnerships are discussed in this paper.

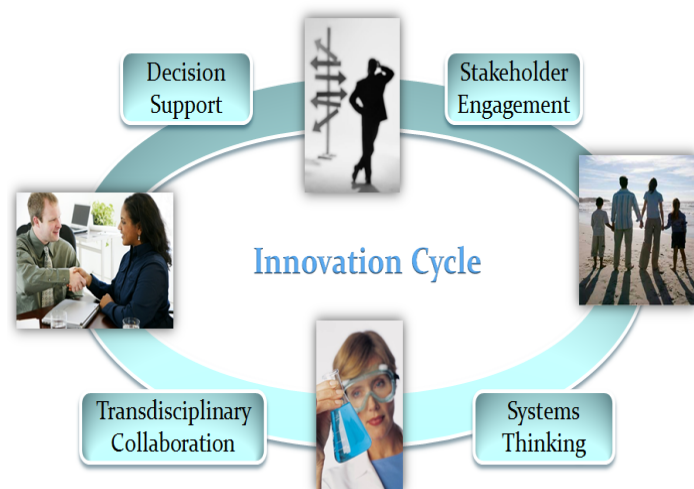


Figure 1. The innovation cycle for Resilience and Sustainability [5]

System thinking is an approach that recognizes economic, social, and environmental activities are all interrelated. A strong case for the need to link disciplines for achieving resiliency and sustainability was clearly presented in the 2017 NIC report. The study points out that “institutions overseeing single sectors will increasingly struggle to address the complex interdependencies of water, food, energy, land, health, infrastructure, and labor.” It is essential to advance an integrated and systems management approach for enhancing economic growth and achieving sustainable and resilient outcomes.

For example, EPA Region 2 (serving New Jersey, New York, Puerto Rico, the U.S. Virgin Islands and eight Tribal nations) is working with the Western New York Sustainable Business Roundtable (SBR), a business-driven organization, to revitalize the Buffalo-Niagara region of New York by advancing a “green economy.” The partnership is exploring systems approaches to spark economic development while also increasing efficiency

and reducing costs and waste. New businesses are forming, existing businesses are expanding, and individuals, corporations, investors, and financial institutions are returning to and investing in the area. As the Western New York SBR strives to realize its vision of an environmentally and economically resilient community, it has commitment to applying the triple bottom line system model to help guide future decisions [6].

The concept of transdisciplinary collaboration brings together all stakeholders to advance the multi-science needs to effectively plan for the future. Achieving the goal of sustainability requires understanding and management of unprecedented and interconnected challenges.

The application of decision-support tools, which is a key focus of this paper, is critical in helping communities understand future impacts and make good decision. This was a clear message of the 1988 House Science Committee report “Unlocking Our Future” which noted that “While acknowledging the continuing need for Science and engineering in national security, health and the economy, the challenges we face today cause us to propose that the scientific and engineering enterprise ought to move toward center stage in a fourth role, that of helping society make good decisions. We believe this role for science will take on increasing importance as we face difficult decisions related to the environment [7].”

EPA is a critically needed federal agency in developing and applying DSTs. To better understand how its tools were being used and could be improved, EPA in 2013 asked the National Academy of Science (NAS) to evaluate its tools and provide guidance for incorporating resilience and sustainability into them in order to meet the anticipated future needs of the Agency and its partners. The resulting NAS Report [8] outlined dozens of recommendations for EPA actions, the essence of which are summarized in the following seven points:

1. Improve communications to stakeholders and the general public about what the tools are, why they were developed, who is using them, and how they contribute to achieving sustainable outcomes.
2. Highlight/showcase the application of tools that led to more sustainable decisions by publicizing case studies through outreach and science communication efforts. EPA should showcase why these tools are successful, and highlight regional success stories.
3. Expand cooperation and partnerships with all stakeholders on developing and using tools to achieve sustainable outcomes. EPA should convene meetings with stakeholder to: (1) learn of their successes, (2) illuminate reasons for limitations in applying tools, and (3) identify specific priority issues and tools that could support actions to address them, such as children’s

health, environmental justice and disadvantaged communities, contaminated lands, urban development, and (4) advance both present and future sustainability challenges.

4. Assess data needs and gaps in the application of decision support tools such as need for Life Cycle Assessment (LCA), Budget analysis, and systems analysis.

5. Promote the application of integrated decision support tools across all programs. This includes demonstrating the reason for and application of systems analysis and LCA. Where possible integrated application of risk assessment, LCA, and economic tradeoffs should be done.

6. Focus more on: (1) anticipating and preparing for impacts from megatrends, (2) uncertainty analysis, and (3) assessing and predicting vulnerabilities and resilience in both urban and rural communities.

7. Make the goal of achieving sustainable outcomes a key element of (1) the enforcement of existing regulations, (2) risk assessment and risk management, and (3) future planning.

Current actions by EPA strongly reflect these recommendations, especially related to working directly with states and communities to support their information needs and improve local decision making. Additionally, EPA is advancing education and public awareness of tools, which is one of the main goals of this paper.

What follows is a discussion of meeting state, city, community, and Tribal needs to achieve community resilience, protect human health and wellbeing, and sustain ecosystem services.

Meeting State, City, and Community Needs

Applying the innovation cycle is crucial for meeting the environmental and related public health challenges that cities and states face, which effects most of the world's population. In 2008, for the first time in human history, more people lived in urban areas than in rural areas, and the pace of urbanization continues to increase. Globally, urban populations are expected to double by the year 2050, reaching 6.2 billion people. Since cities are critical for economic stability, cities and industries must effectively deal with the combined impacts of that population growth as well as other megatrends. This is especially true for economically disadvantaged communities, which are more vulnerable to pollution and natural hazards.

Hence, stakeholder collaboration with cities and states is critical. Since 2009, EPA in cooperation with the Department of Housing and Urban Development (HUD) and Department of Transportation (DOT) have collaborated to ensure their policies and investments better serve American communities. Through these efforts, more than 1,000 communities in all 50

states, Washington, D.C., and Puerto Rico have received more than \$4 billion in grants and technical assistance to help them grow and improve their quality of life.

In August 2014, the Partnership released a report "Partnership for Sustainable Communities: Five Years of Learning from Communities and Coordinating Federal Investments [9]." The Report, which commemorated the fifth anniversary of the HUD-DOT-EPA Partnership for Sustainable Communities, shows how the three agencies are changing their policies and removing barriers to help communities provide more housing choices, make transportation systems more efficient and reliable, and create vibrant neighborhoods while protecting the environment.

The report is part of EPA's Smart Growth Program which helps communities achieve their desired development goals, improve quality of life, and become more economically and environmentally sustainable. New effort today under the "Building Blocks for Sustainable Communities Program" provides additional technical assistance to selected communities using a variety of tools that have demonstrated results and widespread application. EPA has selected 25 communities to receive Building Blocks assistance [10].

To also assist cities and better educate the public, EPA also recently launched a webinar series entitled "EPA's Global Change Explorer Web Tools Collection," which showcases three web tools that help access future changes. The tools provide access to data for assessing the vulnerability of air, water, ecosystems, and human health to climate change, land use change, and other large-scale environmental stressors [11].

Pressures on cities have led nongovernment groups, such as the Smart Cities Council, to advance innovation, science, and resilience. Federal agencies working with Smart Cities have developed a web link offering an inventory of tools and approaches. The "Smart Cities and Communities Resource Guide" is available on the Networking and Information Technology Research and Development (NITRD) web site [12]. EPA activities highlighted feature the decision support tools needed to advance resilient and sustainable communities.

Leadership and coordination among state and cities leaders is a critical activity of EPA's Office of Research and Development (ORD), which is partnering with the Environmental Council of the States (ECOS) and its research arm, the Environmental Research Institute of the States (ERIS), to help states address current environmental problems.

Over the past six years, ERIS and ORD established a partnership, and through a series of direct meetings and surveys have identified specific EPA scientific and technical capabilities to align with state research priorities and needs. As a result of this effort, ORD better understands the science needs of state

environmental agencies, and states have a better understanding of EPA's research and decision support tools. As recently as 2016, states identified their needs and grouped them into broad topics including: water, emerging contaminants/toxics, waste/remediation, and air/ozone. EPA has recently published a document summarizing how ORD's work during the past five years—in partnership with state agencies, counties, communities and universities—has supported states in their efforts to protect human health and the environment [13].

Examples cited in the report highlight a wide range of research, development, decision support tools, and technical assistance focusing on air and water pollution, chemicals, Superfund site remediation, infrastructure, and homeland security.

One of the many examples highlighted is the link between energy, water and food production, and security. This is a systems thinking approach referred to as “the nexus of food, energy, and water [14].”

Through this cooperation, EPA, the Department of Energy, and other partners are developing modeling and simulation tools that can be used to better understand the interactions between agriculture, energy, water, and air systems. In turn, that work is then used to develop innovative processes and strategies that improve the agricultural, commercial, industrial, and water security sectors.

The partners are also conducting research to enhance the resiliency of the nation's water infrastructure and study ways to beneficially reuse and recycle materials used in industrial production. All of these tools illustrate EPA efforts to not only meet its statutory obligations under current environmental legislation, but to do so in ways that efficiently ensure a resilient and sustainable future in the face of the growing pressures highlighted below.

In applying these tools and approaches, EPA has focused on disadvantaged communities. The EPA effort on “Making a Visible Difference in Communities” (MVD) aims to assist communities that are disproportionately impacted by pollution and economic distress [15].

More than 50 environmentally and economically distressed communities have been identified. One example is EPA working with community leaders in Lawrence MA, where critical water treatment infrastructure was in danger of flood and failure. The challenge there was to protect the water quality of the Merrimack River, plan for resiliency of the local water treatment plant, and protect vulnerable populations who use the river for recreation. Work is continuing on flood risk reduction and engineering design. This project, along with others, highlight that community engagement and the use of EPA tools can address community needs.

Beyond the application of decision tools, EPA aims to measure trends and inform the public of major changes. One example of EPA's role in educating the public is the Agency's *Report on the Environment* (ROE) which was first published in 2003 and is now available on an interactive website [16].

The ROE shows how the conditions of the U.S. environment and human health have been changing over time, presenting 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. Examples of questions being addressed include:

- What are the trends in greenhouse gas emissions and concentrations and their impacts on human health and the environment?
- What are the trends in the extent and distribution of the nation's ecological systems?
- What are the trends in the extent and condition of fresh surface waters and their effects on human health and the environment?

The full list of 23 questions is available on the site mentioned above.

Achieving Resilience and Sustainability

Community resilience is now critical for protecting health and the environment and reducing the economic costs associated with the increasing frequency and intensity of natural disasters. Resilience is especially urgent for protecting urban infrastructure. A recent hearing before the House Committee on Transportation and Infrastructure's Subcommittee on Economic Development, Public Buildings, and Emergency Management (4/27/2017) emphasized the impact of extreme weather events and the need to build resilient infrastructure to mitigate damage and recover quickly from disasters. For their current efforts, they note that strong infrastructure requires that we “must be able to meet the needs of today, but also be poised to address the challenges of tomorrow. Together, we must work to build a 21st century infrastructure for America; one that looks for long-term solutions to our challenges and embraces American innovation.”

Building resilient infrastructure is a critical goal for business standards as defined by the new BS 65000 Guidance for Organizational Resilience. These standard help companies adapt successfully to unforeseen and disruptive changing environments. Overall the aim is to reduce costs and protect society from natural and manmade disasters.

Today, many coastal areas are undergoing major challenges and are facing a variety of challenges including flooding, pollution and algal blooms, and catastrophic impacts from coastal flooding. About 40% of the US population lives and works in coastal communities where the overall economy contributes 7.65\$ trillion to the GDP and employs 53.6 million people earning wages of about \$3 trillion (data from NOAA National Ocean Service.)

One clear threat to infrastructure in coastal communities is the pace of sea level rise which has nearly tripled since 1990, due largely to an acceleration in the melting of ice sheets in Greenland and Antarctica. According to new studies, oceans were rising before 1990 at about 1.1 millimeters per year, or just 0.43 inches per decade. But from 1993 through 2012, the study has found that sea level is rising at 3.1 millimeters per year, or 1.22 inches per decade [17].

Researchers estimate that preparing coastal cities, repairing property damages, and relocating inhabitants for future sea level rise could have a roughly \$500 billion price tag by 2100. But storm surge from tropical cyclones can cause additional local rises in sea level rise resulting in about \$1 trillion in additional damage [18].

The US Gulf Coast states (TX, LA, MS, AL, FL), collectively representing a critically important region for the overall US economy, are now embracing serious investments and efforts to increase resiliency and sustainability as an insurance against large-scale storms and other threats.



EPA and the Federal Emergency Management Agency (FEMA) are working together to help Gulf Coast communities become safer, healthier, and more resilient. Through a memorandum of agreement (MOA,) EPA and FEMA work together to support communities hit by disasters so they can rebuild in ways that incorporate environmental protection, spark sustained and long-term economic prosperity, and enhance neighborhoods for the benefit and wellbeing of their residents. Specifically, the MOA reflects a mutual goal of working with communities “to reduce vulnerability to natural hazard events, recover from disasters that occur, and achieve economic, environmental, and public health outcomes as part of redevelopment and recovery efforts.”

Disaster events are common in the Gulf Coast. In March and August of 2016, the State of Louisiana experienced two federal Major Disaster Declarations, both of which included significant flooding. Fifty-six of Louisiana’s sixty-four parishes were designated by FEMA as having sustained serious damage from one or both floods. EPA Region 6 Sustainability Advisors work with FEMA on a variety of activities and projects focusing on disaster recovery and resiliency in the state. Activities include supporting the use of EPA Smart Growth tools. For example, EPA and FEMA participated in a Flood Resilience for Riverine and Coastal Communities technical assistance workshop that utilized the EPA Flood Resilience Checklist.

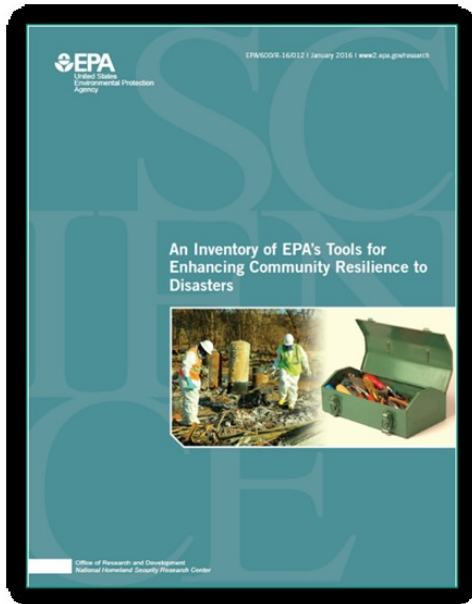
The checklist can help communities identify opportunities to improve their resilience to future floods through policy and regulatory tools, including comprehensive plans, Hazard Mitigation Plans, local land use codes and regulations, and non-regulatory programs implemented at the local level [19]. The Gulf Research Program (GRP) of the National Academies of Sciences (NAS), using funds from settlement of the BP Oil Spill, is also funding projects that enhance the science and practice of coastal community resilience in the region. These projects will explore the interrelated health, social, environmental, and economic impacts of disasters and other environmental stressors and inform strategies to address these challenges in Gulf communities. EPA has advised the NAS on activities and is working to protect ecological conditions in the Gulf Coast.

In the Gulf Coast community, New Orleans is one of the Rockefeller Foundation’s 100 Resilient Cities. As noted in the introduction, as a Platform Partner of 100 Resilient Cities, EPA is providing scientific tools to help cities become more resilient. Two tools being used, TEVA-SPOT and Emergency Water Supply are described below.

To assist all parts of the US to meet challenges from the pace and extent of megatrends, EPA has developed a number of tools to help build a resilient society. Agency researchers have developed an “Inventory of EPA’s Tools for Enhancing Community Resilience to Disasters,” which reviews and summarizes many of the EPA tools available for federal partners, states, local governments, utilities, communities, and individuals to help increase resiliency to disasters. The tools presented can be directly applied for preparing, mitigating, preventing, responding to, and recovering from disasters, and for improving overall community resilience to both natural and man-made hazards and disasters. The tools include online mapping systems, guidance documents and publications, and many other resources. Several of the tools were originally developed for homeland security applications—supporting response and recovery efforts in the aftermath of chemical, biological, radiological, or nuclear events—but can be used for recovering from other events as well.

These and many other tools can help communities better pre-

pare for a future that will be affected by the megatrends of climate change, population growth, and increases in extreme weather events.



Resilience is critical in dealing with a variety of water-related stresses including drought and watershed management, storm water and flood management, sea level rise and coastal erosion, water contamination, and aging infrastructure. EPA tools that can help build resilience in water resources, all of which are available on EPA web links, include:

- **CANARY and TEVA-SPOT:** Provides early warning and detection of harmful contaminants in drinking water distribution systems.
- **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.
- **Emergency Water Supply planning guidance:** Provides guidance on how to plan for disruptions in drinking water services.
- **Climate Resilience Evaluation and Awareness Tool (CREAT):** Allows water utility stakeholders to explore long-term impacts of climate change and adaptation strategies.

A new tool is being developed by EPA that measures a community's or county's resilience capacity following an extreme climate event. The Climate Resilience Screening Index (CRSI) is a multi-spatial index that integrates exposure history, exposure likelihood, technological co-exposure, and governance to address basic resilience. Then basic resilience is modified into the index score by an adjustment associated with societal, economic, and built and natural environment attributes. CRSI integrates the exposure histories of all counties for hurricanes,

tornados, floods (inland and coastal), wildfires, severe temperature changes, landslides, hail, earthquakes, drought, and wind events.

The index integrates these exposure, governance, and adjusting characteristics through the use of five domains, 21 indicators, and more than 100 metrics [20]. The index is being applied to all counties of the United States and can be exercised at smaller spatial scales (e.g., communities, census tracts) through the use of a spatial imputation tool called MERLIN [21]. In addition, the index can be disassembled to what attributes in a community are either increasing or decreasing their resilience. Finally, the index can be used as an educational tool to demonstrate best practices for the development of community resilience. CRSI will be available in late 2017.

In addition to the above tools, EPA has also developed a "Water Infrastructure and Resiliency Finance Center" to help communities across the country improve their wastewater, drinking water, and storm water systems, particularly through innovative financing and building resilience to climate change. The Center seeks to accelerate and improve the quality of water infrastructure by identifying financial solutions and providing technical support to help communities meet infrastructure needs. In a positive way, all of these activities go beyond any traditional legislative mandate.

Protecting Human Health and Wellbeing

Human health and wellbeing are influenced by a variety of factors, including urban development and exposure to environmental pollutants from industrial production. EPA's core research seeks to understand the links between air and water quality and human health, with the goal of designing systems that reduce, neutralize, or eliminate threats. EPA's Healthy Heart program aims to prevent heart attacks and strokes by raising public awareness about the role outdoor air pollution plays in cardiovascular health, and identifying steps individuals can take to reduce their pollution exposure [22].

In addition, to informing community decision making, EPA is striving to develop a holistic understanding of how the built, natural, and social environments influence human health and wellbeing, especially for sensitive populations and life stages such as children and the elderly.

Among the many decision-support tools (also available on web links) are:

- **The Community-Focused Exposure and Risk Screening Tool (C-FERST).** Community engagement is crucial in helping citizens define and prioritize environmental and public health issues where they live, work and play. EPA's Community-Focused Exposure and Risk Screening Tool (C-FERST) provides information to help users identify environmental issues in their

communities, learn about these issues, and explore exposure and risk reduction options. Communities and decision makers can use C-FERST along with local information to advance community environmental health and wellbeing. See map and user guide at:

- ORD researchers are developing a Chemical Dashboard to facilitate understanding of chemical impacts on human health and the environment. This tool enables the user to evaluate information on chemical exposure, hazard, risk, sustainability, predictive models and decision-rules. Advances in computational toxicology allow this Dashboard to integrate these diverse sources of chemical information and enable more rapid and less costly screening of chemicals.

- The newly developed Eco-Health Relationship Browser (part of EnviroAtlas described below) illustrates the linkages between human health and ecosystem services—that is, the benefits supplied by Nature. This interactive tool provides access to published literature on our nation’s major ecosystems, the services they provide, and shows how those services may affect people.

- The Human Well Being Index (HWBI), introduced in 2012, is an index that links ecosystem, economics and social services to human wellbeing. [23]. Built upon county level data, it will enable decision-makers to visualize and model the influences that community and natural resource decisions may have on well-being, and to compare alternative approaches for fostering community sustainability. The HWBI incorporates 8 domains of wellbeing, described by 27 indicators, weighted by relative importance values. Tracked over time, the index and its domain components have the potential to serve as measures of sustainable human well-being when linked to alternative decisions that change the ecological, economic, and social states of defined populations. In addition to applications throughout the United States, HWBI has been adapted to assess the wellbeing of Native American [24] and children [25] finally, the services evaluated in HWBI have been used to develop a forecasting tool to examine the intended and unintended consequence of decision (e.g., location and building of a new school, infrastructure projects, job initiatives) on community wellbeing at the community or county level.

- Environmental Quality Index assesses how overall environmental conditions and multi-pollutant domains might be connected to adverse health outcomes. Data has been collected for all counties in the U.S.

To advance these and other tools, EPA is collaborating with many states, cities, and Tribal communities. Tribes face unique and numerous environmental and human health challenges. As Tribal leaders work to build and enhance environmental safeguards in their communities, user-friendly, science-based tools may contribute to sustainable solutions. Tribal-based tools are needed to prioritize environmental issues, illuminate

exposure pathways, and conduct comprehensive impact assessments—all of which are important in decisions to improve public health and the environment.

EPA’s Tribal-Focused Environmental Risk and Sustainability Tool (Tribal-FERST) is a web-based tool designed to provide Tribal leaders with information to prioritize environmental issues, understand exposure pathways, and conduct comprehensive impact assessments. The key aim of application is to provide access to relevant science that can be used to develop sustainable, cost-effective solutions for reducing environmental exposures and health risks. Using this web-based geospatial decision support tool, Tribes may employ a holistic approach to address environmental concerns and plan for the future.

Tribes and partners throughout the United States are providing input on the design and content of this tool. The Pleasant Point Passamaquoddy Tribe of Maine is currently piloting Tribal-FERST, working with the Sustainable and Healthy Communities research program. This collaboration draws together tribal members, EPA, and the Tribe’s sustainable community planning consultants, in order to make informed decisions about how to deal with environmental challenges such as solid waste, sea level rise, and subsistence diet.

Sustaining Ecosystem Benefits

To achieve a resilient and sustainable future, we must reduce adverse human impacts on existing natural resources, and we must anticipate and respond to future impacts from climate change and other forces. For example, it is important to understand the local, national, and global impacts of energy choices we make in terms of human health, natural resource availability, and ecosystem services. Likewise, it is important to address the overabundance of nitrogen and phosphorus in U.S. waters, which poses threats to the health of both humans and ecosystems. Reactive nitrogen contributes to smog and decreased visibility, acidification of ecosystems, eutrophication of water bodies, decreased drinking water quality, greenhouse gas emissions, ozone depletion, and respiratory and cardiac diseases.

EPA New England Region 1 (serving Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont and 10 Tribal Nations) and ORD collaborated on a systems modeling project to address the problem of nutrient impairment in sensitive waterways. The approach was piloted in the Narragansett Bay watershed through development of a policy simulation tool that draws from watershed-specific data and extensive stakeholder input. The tool, called Narragansett-3VS (Triple Value Simulation), features a dashboard-style visualization interface that enables users to explore different scenarios, interpret results, and evaluate outcomes of new policies or interventions [26].

Region 1 is now replicating this systems approach in the Cape

Cod area, while similar 3VS models are being designed to address sustainability issues in other regions of the U.S. Region 3 (Delaware, District of Columbia, Maryland, Pennsylvania, Virginia and West Virginia) are also addressing the problem of nutrient pollution from urban storm water runoff in the Chesapeake Bay area. Using a systems model, scientists and the community will collaborate to reduce storm water pollution, maintain long-term water quality in Chesapeake Bay, and protect the health of the community. Application of decision support tools include:

One of EPA key tool for ecosystem protection is the EnviroAtlas which is a web-based mapping application that allows users to view and analyze multiple ecosystem services in a specific region such as drinking water supplies or recreational amenities. Decision makers can use the Atlas to forecast what will happen to these natural resources under future population or climate changes. By 2019, Enviro Atlas will grow to include over 50 communities in the United States.

communities to direct their land development strategies along a path that will sustain the ecosystem services necessary to protect the environment and human health. PLACES resembles green building programs such as Leadership in Energy and Environmental Design (LEED), Smart Growth, Sustainable Sites Initiative, and Green Globes, but it addresses entire communities [27]. The PLACES tool is being applied in collaboration with EPA, Kansas State University, and EPA Region 7, helping the town of Stella, Missouri to adopt more sustainable land development policies.

- ORD's Storm Water Management Model (SWMM) simulates storm water runoff and impacts on combined sewers, sanitary sewers and other urban drainage systems. It supports planning, analysis, and design of alternative storm water management to reduce flooding, combined sewer overflow, nutrient impairment of water bodies, and health risks.

- An important new tool released in July 2013 is the National Storm Water Calculator; a desktop application that estimates the annual amount of storm water runoff from a specific site

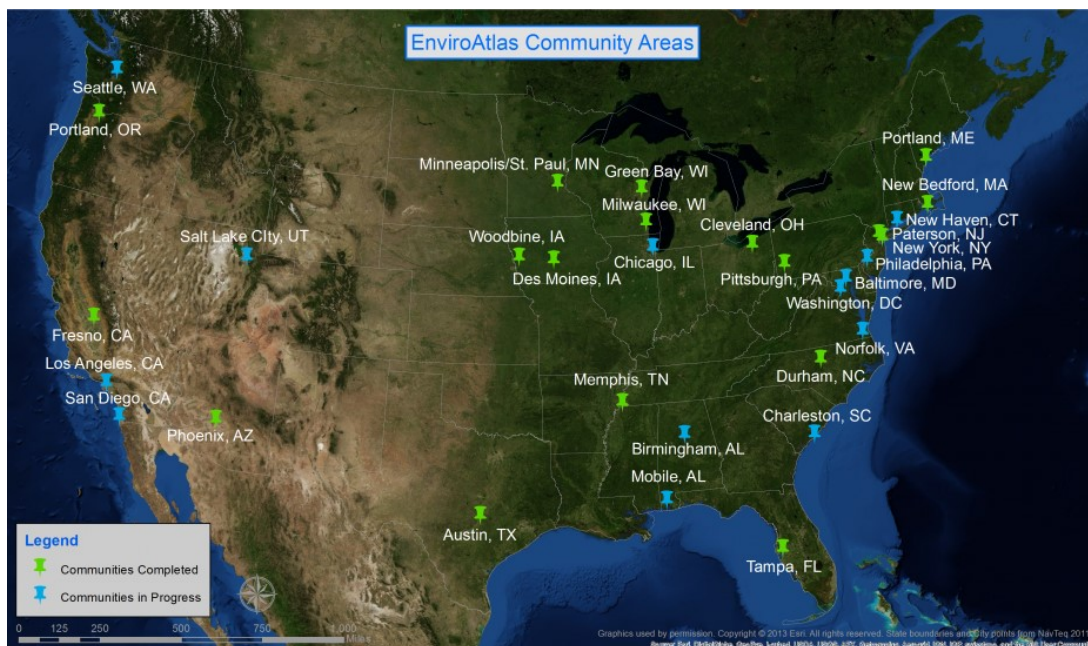


Figure 2. From <https://www.epa.gov/enviroatlas/enviroatlas-communities>.

The application of the EnviroAtlas is to help evaluate and apply ecosystem services to inform decisions, research and education. It also provides information at multiple spatial resolutions from watersheds to fine-scale community data and it enables users to identify and analyze synergies and tradeoffs in ecosystem services.

Other key tools for natural resource protection are:

- An ORD tool called PLACES (Planning Land and Communities to be Environmentally Sustainable) encourages and enables

based on local soil conditions, slope, land cover, and historical rainfall records. Users can enter any U.S. location and select different scenarios to learn how a variety of specific green infrastructure changes, such as rain gardens and permeable pavements, can prevent pollution. Green infrastructure approaches also provide protection from flooding, energy savings, improved air quality, increased property values, and healthier communities, other projects that involve extensive collaboration with cities, states and federal agencies:

- ORD is working with the city of Omaha and the Nebraska

Department of Environmental Quality to provide guidance on how the city and state can incorporate green infrastructure into their combined sewer overflow control plan. Similarly, ORD is helping the City of Cleveland with assessment, evaluation, and adaptive management of green infrastructure solutions.

- ORD is partnering with a number of collaborators, including the Tampa Bay Estuary Program and the Tampa Bay Regional Planning Council to develop tools for assessing the value of ecosystem goods and services, including climate regulation, biodiversity support, culture and aesthetics, flood protection, and provision of food, fiber, clean air, and usable water.

- ORD and SHC is partnering with the City of Denver Housing Authority and EPA Region 8 to examine the impact of the sustainable and eco-friendly redesign of the Sun Valley community in Denver on the well-being of its residents and the residents of adjoining communities.

ORD established the “Technology Innovation Clusters”, in collaboration with businesses, federal agencies, local governments, universities, investors, and others, to promote environmentally sustainable economic development and technological innovation in defined geographic areas. This has led to formation of a water technology cluster in Ohio, Kentucky, and Indiana [28].

Extensive ORD cooperation is also underway with the U.S. Army and Department of Defense to support their resource security and resilience efforts, intended to create more sustainable and secure installations and facilities. This cross-agency collaboration is evaluating new technologies to improve efficiency and minimize waste of resources.

A broader effort to promote “net zero” water energy and waste strategies is now being expanded to communities. An EPA workshop in 2014, “Promoting Sustainable Communities through Net Zero Strategies” brought community leaders and Federal agencies gathered to discuss barriers, solutions, and lessons learned from implementing Net Zero water, waste, and energy strategies at various scales. They also discussed ways in which EPA and other Federal agencies can support community sustainability efforts. Since this workshop EPA is pursuing several projects that will aid communities in their Net Zero Water, Energy, and Waste efforts.

For example, EPA began developing a web-based search tool that connects users to EPA’s green infrastructure and materials management decision-making resources. The aim of Net Zero is to consume only as much energy as produced, achieving a sustainable balance between water availability and demand, and eliminating solid waste sent to landfills. EPA’s research focuses on pooling federal, state and local expertise and resources to make a positive impact on a grand scale while fostering economic growth and promoting citizen health and well-being [29].

Looking Ahead: EPA at 50

It is especially important today for the public to understand the history of environmental protection. Environmental stresses of the 1960’s led to the enactment of National Environmental Policy Act (NEPA) in 1969 and the creation of EPA in 1970. In the early 1970’s EPA became an environmental regulator and policeman. But over the past few decades, EPA has taken the necessary steps to keep pace with increasing complexity and impact of emerging environmental and public health challenges facing the nation, embracing the scientific and innovative leadership expertise necessary to provide timely, responsive research results to meet current priorities while laying the foundation necessary to address future problems.

EPA has learned that regulations and traditional approaches to risk reduction and pollution control are limited in their ability to deal with the interplay between different media and work toward their “synergy.” Hence the goal of sustainability was embraced as a step to achieve outcomes that enhance the economy and protect health and the environment.

While today we may still have to deal with the impacts of single sources of pollution (particularly chemical contamination) and its impact on human health, the major of national problems we face today reflect the integrated impacts of land, energy and water use, overall resource depletion, and population growth, especially in urban communities.

EPA’s future plans should build on current work but aim to effectively respond to growing external pressures. Growing pressures from megatrends are a major challenge for the new Administration and for cities and states across the country. The current emphasis on federal state cooperation and application of decision support tools to enhance resilient and sustainability remains a major priority. The recent hurricanes hitting Texas and the Gulf Coast, part of the increase in extreme weather events, make it clear that building resilient infrastructure is a crucial step to sustainability.

In dealing with problems of the future, the National Academy of Sciences (NAS) has 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* [30]”. Hence, it is clear that EPA, other agencies, states and communities and the business world must collaborate to ensure a strong and safe economy. Society must transcend the traditional conflicts between business and government, and build bipartisan support.

It is here that we must take actions that enhance economic growth while protect health and the environment. It is here that EPA’s efforts on science and innovation are crucial and why EPA collective efforts outlined in this paper can be as much an “Economic Productivity Advocate” as an

“Environmental Protection Agency.”

Disclaimer

Views expressed in this article are those of the authors and does not necessarily reflect the views or policies of the U.S. Environmental Protection Agency (EPA). Mention of trade names or commercial products does not constitute agency endorsement or recommendation for use.

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