SCIENCE AND TECHNOLOGY FOR SUSTAINABILITY

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

SUMMARY

SUSTAINABILITY FOR THE NATION

Resource Connections and Governance Linkages

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A "sustainable society," according to one definition, "is 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."[1]

As federal agencies work to ensure sufficient fresh water, food, energy, housing, health, and education for the nation while trying to maintain its resources for future generations, they discover that they are not well organized to address the crosscutting nature of sustainability issues. Complex challenges such as managing ecosystems or improving disaster resilience, for example, do not fit neatly into a single agency's mandate or a single area of expertise. Governing for sustainability will require building "linkages" among federal, state, and local governments; nongovernmental organizations (NGOs); and the private sector.

The National Research Council was asked by several federal agencies, foundations, and the private sector to provide guidance to the federal government on issues related to sustainability linkages. To undertake this task, the Research Council appointed a committee with a wide range of expertise in government, academia, and business. In the course of its study, the committee held public fact-finding meetings to hear from agencies and stakeholder groups; examined sustainability management examples; and conducted extensive literature reviews to inform its deliberations and discussion.

A National Sustainability Policy is needed to help agencies overcome current barriers to making effective decisions related to sustainability, concluded the committee in its report, *Sustainability for the Nation: Resource Connections and Governance Linkages*. The report also offers an analytical framework to aid government decision making on issues where linkages are vital, identifies high-priority sustainability challenges that need greater interagency cooperation, and recommends other steps agencies can take to break down barriers to successful collaboration.

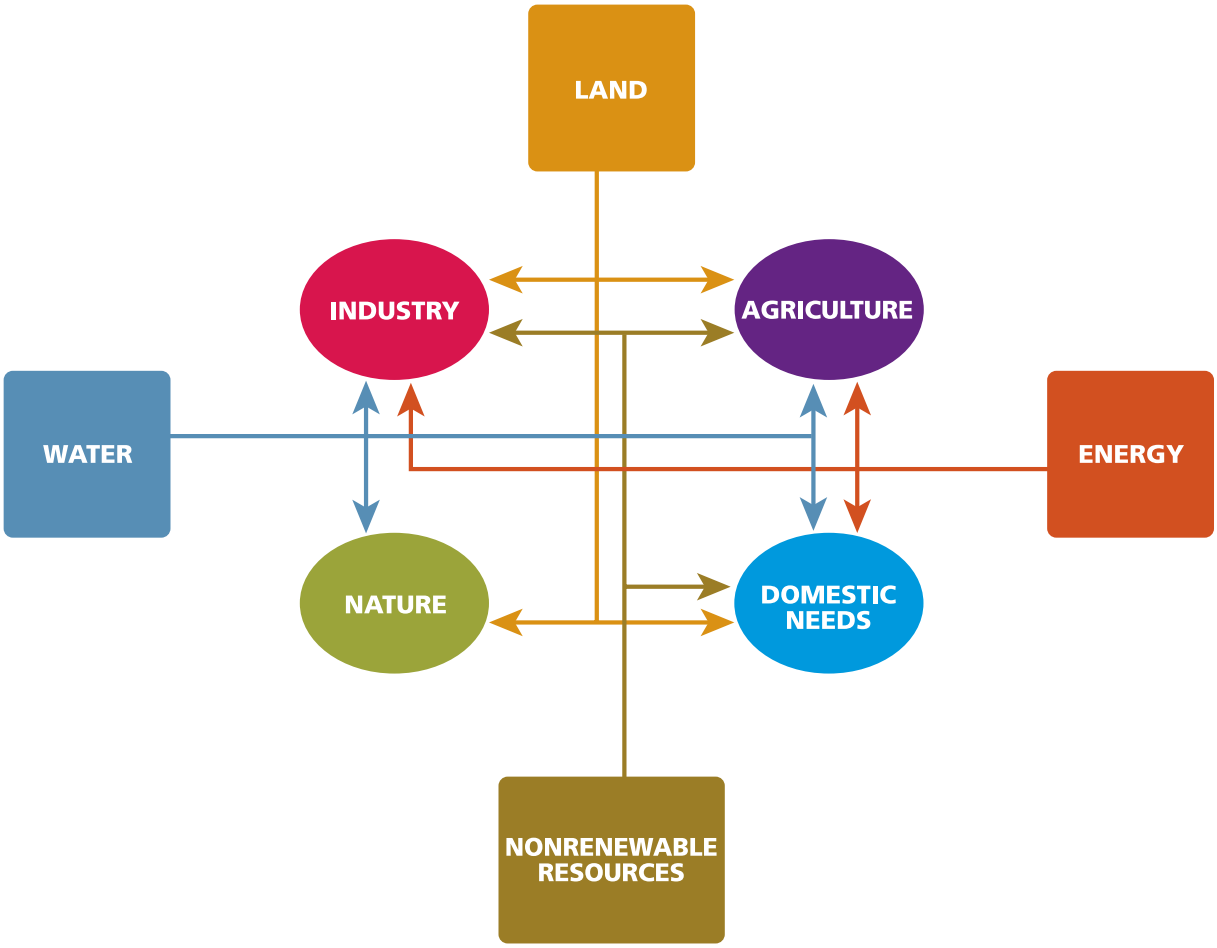
This booklet summarizes the report's findings and recommendations, and describes real-world examples of how agencies and stakeholders have built linkages to address sustainability challenges.

[1]Meadows, D. H., D. L. Meadows, and J. Randers. 1992. Beyond the Limits. White River Junction, VT: Chelsea Green Publishing.

Considering Connections, Building Linkages

The legendary ecologist John Muir wrote in 1911 that "when we try to pick out anything by itself, we find it hitched to everything else in the Universe." His perceptive statement applies to water, land, wildlife, and other aspects of the natural world, as well as to the interactions that link humans and nature. Many decades later, it is obvious that the statement is also relevant to how the nation governs its resources. Governing for sustainability requires:

- **Considering *connections* across resource areas.** For example, managing water resources sustainably means considering not just water quality and quantity but also water's connections to other domains. Water is connected to agriculture because it is used for irrigation and because agricultural runoff affects water quality. Water is connected to energy because managing water requires energy, and because water can be used to produce energy through hydropower. Water quality and availability affects human health, as well as recreation, fisheries, and animal habitats.
- **Fostering *linkages* across agencies and other organizations.** Governance by its traditional nature—and often by statute—is compartmentalized, but focusing on a single element in an interconnected system is a path to less-than-optimal results. By acknowledging the linkages across societal and governance institutions, agencies can bring the right complement of people to the table for sustainability-related decision making. Thus, managing water resources would require effective linkages among dozens of federal, state, local, and sometimes international institutions and organizations.



SOURCE: Graedel, T.E., and E. van der Voet, 2010, adapted from Figure 1.2. The links among the needs for and limits of sustainability. Reprinted with permission from the MIT Press.

When coping with complex sustainability issues, government agencies are likely to achieve better results if they manage connections and promote governance linkages. The figure above depicts the challenge. Key resource domains, including water, land, energy, and nonrenewable resources, are shown as squares. Areas that need those resources—industry, agriculture, nature, and domestic needs—are shown as ovals. As the diagram shows, a near-complete connection exists among all of these domains. Nevertheless, scientists and decision makers typically specialize in one resource domain or one group of resource users and are relatively unaware of the constraints that may exist because of their area's connections with others.

While it may be challenging to address connections across natural resource domains and groups of resource users, successful governance requires overcoming these challenges. Ignoring connections and neglecting linkages raises the risk that policy actions will be ineffective or lead to unintended consequences.

Priority Issues for Building Sustainability Linkages

What sustainability issues are the most important ones for the nation to address? The committee identified four high-priority sustainability challenges of national importance that involve connections among many social and natural resource areas. These challenges cannot be effectively addressed by a single agency acting alone. Rather, managing them sustainably will require creating linkages to enable greater interagency cooperation.

Connections among energy, food, and water. The availability and abundance of affordable supplies of energy, food, and water are vital to sustaining healthy populations and economic prosperity.

Producing and using energy often involves consuming water and can also impact water quality, air quality, and land use. For example, intensive production of corn for ethanol both requires water for irrigation and affects water quality; chemical fertilizers that are heavily applied to corn run off into streams and rivers and become a major source of pollution. Some fossil fuel production, nuclear energy facilities, and renewable energy sources also require water for production, processing, cooling, and other purposes.

Diverse and healthy ecosystems. Ecosystems provide services to human communities—such as water supplies, coastal storm buffers, productive fisheries, and pollination. While not well quantified, the economic value of such services represents a significant contribution to the nation's economic health. The actions of many agencies affect these ecosystems, and managing ecosystems to sustain their benefits and long-term health often requires working at large scales.

Enhancing the resilience of communities to extreme events. Improving the sustainability of communities means identifying their vulnerabilities and enhancing their resilience in the face of both catastrophic events—such as severe weather, earthquakes, or terrorist attacks—and more gradual processes, such as climate change. For example, climate effects such as sea level rise and storm surge

can result in coastal flooding, which in turn affects transportation, communications, water supplies, and energy services. Currently, the nation's capacity to manage such interdependencies remains limited. More-coordinated strategies are needed to address vulnerabilities in infrastructure and promote resilience in communities.

Human health and well-being. Sustainability efforts may affect human health and well-being in complex, crosscutting ways. For example, agricultural practices influence the nutritional content and contaminant levels in food, as well as its availability and price. Land use and transportation decisions affect levels of physical activity, which in turn influence the risk of cardiovascular disease, many cancers, and other conditions. Environmental policies affect the probability of exposure to toxic chemicals, contaminated air and water, and hazardous waste. These multiple connections suggest that linkages among many government entities and nongovernment players are needed to achieve sustainability policies that promote human health and well-being.

Philadelphia's Green Stormwater Infrastructure

In the late 1990s, Philadelphia began to encounter a problem faced by many urban areas with older infrastructure: Its rainwater and sewage drained into the same sewer, and when the sewer overflowed during heavy rains, waste was discharged into local rivers. The U.S. Environmental Protection Agency (EPA) requires cities

to address this problem, and most do so by expanding their sanitary sewer or constructing separate systems for runoff and sewage.

Philadelphia ultimately chose a different path: reducing runoff by reusing and managing rainwater. This "Green Stormwater Infrastructure" (GSI) allows rainwater to percolate through the soil wherever possible, using devices such as wetlands, tree trenches, green roofs, and rain gardens, as well as pavement that lets rain soak through rather than run off. Rain barrels promote the recovery and recycling of water.

Philadelphia's GSI has led to cost savings and other remarkably far-reaching benefits, which illustrate connections among the environment, energy, and human health:

Saving energy and mitigating climate change. Shade from trees and plants used as part of GSI insulates buildings from wide temperature swings and lessens the energy needed for heating and cooling. Because rain is managed where it falls in the soil, energy is not needed for traditional systems to store, pump, and treat it. Growing trees also act as carbon "sinks," absorbing carbon dioxide from the air and incorporating it into their branches and trunks.

Conserving water. Rainwater reuse technologies collect, convey, and store rain from relatively clean surfaces such as roofs. The water is generally stored in a tank or cistern and then reused for irrigation or flushing toilets in residential properties, and for boilers and cooling towers in industrial or commercial properties.

Improving public health. Heat waves are a fixture of summers in Philadelphia, including some severe enough to cause premature deaths. The trees and green roofs that are part of GSI reduce the severity of extreme heat by creating shade, reducing the amount of heat-absorbing pavement and rooftops, and by emitting water vapor—all of which cool the air.

The GSI effort was possible not only because the commitment to sustainability was strong at the mayoral level, but also because of the leadership and expertise of key actors from the Philadelphia Water Department. Through local experience and networks, linkages were created with other city departments—such as Philadelphia Parks and Recreation and the Philadelphia Streets Department—and GSI yielded benefits beyond simple stormwater management.

Barriers to Governing for Sustainability

Currently, several barriers frustrate government efforts to address sustainability challenges such as those described. These obstacles impede agencies' ability to fully consider the connections among resource areas and to build the linkages needed to manage them:

- **The separated and dispersed authority that results from the basic legal framework of government.** Many of the laws that authorize agencies focus on a single mission or a single domain—water or energy, for example—even if the domain is part of an interconnected resource system. The pejorative but accurate description for this fragmentation of authority is the "stovepipe" or "silo" effect: Each agency focuses on implementing its own statutory mandate.
- **Funding mechanisms that favor short-term, single-agency initiatives rather than longer-term, cross-agency projects.** Budgets are prepared on an agency-by-agency basis, and agencies typically promote and defend their own initiatives rather than multiagency initiatives. In addition, congressional appropriations committees are reluctant to appropriate funds for matters they view as the responsibility of another committee, even if those matters relate to the mission of an agency within their jurisdiction.
- **A lack of access to or coordination of foundational elements such as research and information/data.** One of the observed consequences of the silo effect is that agencies have traditionally compiled the data they need or have undertaken research for activities they view as their own, independent of their sister agencies. A similar fragmentation often happens with basic and applied research. While there is some coordination among agencies in constructing research portfolios and making results available, individual agencies generally undertake research within their silos, tailored to their own needs and programs.
- **The culture of government,** which tends to encourage agencies and their personnel to "stay in your lane" and avoid getting involved in sister agencies' activities. In addition, rather than encouraging risk-taking or collaboration, this culture tends to offer recognition, promotion, and other rewards based on an employee advancing an agency's agenda in a competent but orthodox fashion.

Fortunately, steps can be taken to overcome these obstacles and create structures and incentives to enable greater collaboration where it is needed or beneficial.

Protecting the Great Lakes

The longest coastline in America's lower 48 states runs not along the Atlantic or the Pacific, but along five connected lakes that together make up the largest body of fresh water in the world. The Great Lakes—Erie, Ontario, Huron, Michigan, and Superior—have played a critical role environmentally, economically, and culturally in the life and history of North America.

Administratively they are very challenging, spanning two countries, eight states, and two provinces, and involving many local governments and native peoples. Given this complexity, the need to build linkages has been strong and ongoing.

One of the first linkages took the form of an international treaty, the Boundary Waters Treaty of 1909, which resulted from a recognition of the Lakes' enormous value and the need to manage them for the benefit of both Canada and the United States. The treaty established the International Joint Commission, made up of three U.S. and three Canadian Commissioners who advise each government on matters of national interest regarding all shared boundary waters, with an emphasis on the Great Lakes. The treaty has provided the foundation for more than 100 years of shared governance, which has evolved in response to various sustainability challenges.

In the 1960s, for example, phosphorus pollution caused Lake Erie to experience such a decline in oxygen that it was declared "dead," and the lake became an icon for water quality problems. The International Joint Commission tasked prominent U.S. and Canadian scientists with determining what an acceptable amount of phosphorus might be, in the context of what was being discharged from sewage plants. The models they produced were the basis for limits on discharge, for a decision by the U.S. EPA and Environment Canada to require primary treatment of sewage, and ultimately for the two nations' respective Clean Water Act statutes.

The International Joint Commission also institutionalized the involvement of stakeholders around the Great Lakes Basin. The area's populace is actively invited to be engaged in and educated about Great Lakes issues and to participate in biennial meetings about priorities for the Basin. The stakeholder community, including NGOs, is well known, visible, and historically very active. For example, activism by this community resulted in a Canadian ban of phosphorus in detergent and the adoption of bans in the United States to reduce levels of the nutrient in water.

The Great Lakes case reveals the importance of establishing and supporting institutions that are sustaining yet adaptable, such as the International Joint Commission; of generating scientific, social, and economic knowledge to inform decision making; and of engaging stakeholders proactively and often.

The Need for a National Sustainability Policy

A National Sustainability Policy could help break down barriers and enable initiatives that cut across jurisdictions and resource areas. The objective of the policy would be to address environmental, economic, and societal issues and support human well-being by:

- Encouraging and promoting coordination among agencies
- Reducing siloed decision making and improving integration of research and operations across the government
- Enhancing communication among agencies and between the federal government and stakeholders at national, state, and local levels
- Reducing duplication of efforts and improving cost effectiveness
- Enhancing the use of existing laws such as the National Environmental Policy Act (NEPA) by providing guidance on how to incorporate sustainability goals and linkages into federal decision-making processes

An optimal National Sustainability Policy would establish the fundamental principle of promoting the long-term sustainability of the nation's economy, natural resources, and social well-being. It would facilitate sustainability initiatives across the federal government, including working with many governmental and nongovernmental partners. It would set out broad general objectives, management principles, and a framework for addressing complex cross-jurisdictional sustainability challenges; however, it should not be prescriptive in its approach, goals, participants, or structure. It would also build collaborative approaches that deal with sustainability connections into the operations of government agencies.

Several models exist for developing a National Sustainability Policy. For example, in 2010 President Obama, building upon efforts begun by President George W. Bush, signed an Executive Order developing a National Oceans Policy. The policy includes a set of overarching principles to guide management decisions, with the goal of ensuring that the nation's oceans, coasts, and Great Lakes are healthy, resilient, safe, and productive in both the present and the future. The policy speaks to the need for linkages similar to those required for sustainability in that it establishes a national framework to address cross-governance challenges, and then engages stakeholders in regular meetings and other interactions designed to stimulate cooperative action.

All stakeholders, including the private sector and NGOs, should be provided an opportunity for contributing to the development of the National Sustainability Policy. Once the policy is in place, agencies should develop specific implementation plans. In implementing the policy, consideration should be given to creating open and transparent oversight involving the public, state legislatures, Congress, and the President.

A Framework for Sustainability

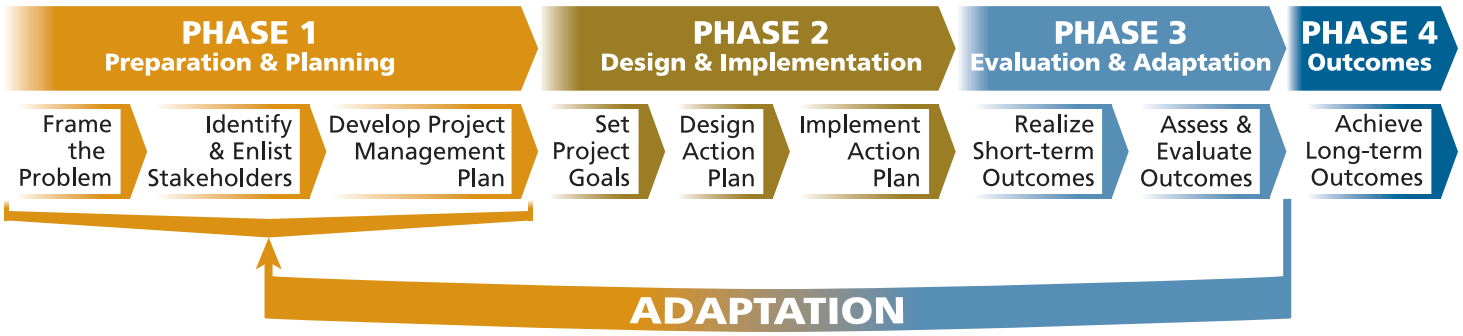
Along with a National Sustainability Policy, the federal government should adopt a practical tool that agencies can use when approaching sustainability issues and projects: a structured decision framework that reflects relevant connections and helps agencies strengthen linkages. Any framework must be flexible enough that it can be applied to a broad range of sustainability challenges. The figure to the right presents a graphic representation of the decision framework recommended by the committee. The framework lays out a process that is structured but flexible from beginning to end, from formulating the problem through achieving outcomes. It should be used on sustainability issues that are complex enough to warrant a multi-agency approach.

PHASE 1: PREPARATION AND PLANNING. This important phase, which is often overlooked or done in an incomplete fashion, includes three major steps that need to occur before the actual program or project is designed.

- **Frame the problem.** This step ensures that the problem to be solved is clearly understood. All dimensions of the problem must be identified, including the environmental resource connections, societal connections, and economic connections. These elements of the problem will inform the selection of agencies and organizations that should be involved in the program or project. This step includes determining baseline conditions, key drivers, metrics, and goals based on those metrics.
- **Identify and enlist stakeholders.** The next step is to identify the relevant agency linkages. Depending on the natural resources and social and economic aspects of the problem, it will be critical to engage all of the federal agencies affected by it. Another part of this step is to identify relevant non-agency stakeholders—nonfederal government agencies, NGOs, private sector interests, and others who are invested in the outcome of decisions and actions. In addition, the individual representatives from the agencies and stakeholders who will serve on the project team must be identified.
- **Develop a project management plan.** The plan should clearly delineate the roles, responsibilities, and accountability of each member organization or participant, as well as a business plan for funding the project's design, implementation, and maintenance.

PHASE 2: DESIGN AND IMPLEMENTATION

- **Set project goals.** The team formalizes goals for the program or project—a step that should be taken with input from stakeholders and relevant members of the public. During this step, the short- and long-term outcomes are developed, as well as how they will be measured.
- **Design an action plan.** In this step, the team develops a comprehensive design of the approach, strategies, and actions needed to meet the goals established in the previous step. The necessary tools, knowledge, and information to accomplish the goals must be identified and pursued, and the team needs to identify who will implement the plan and how the program will be maintained.



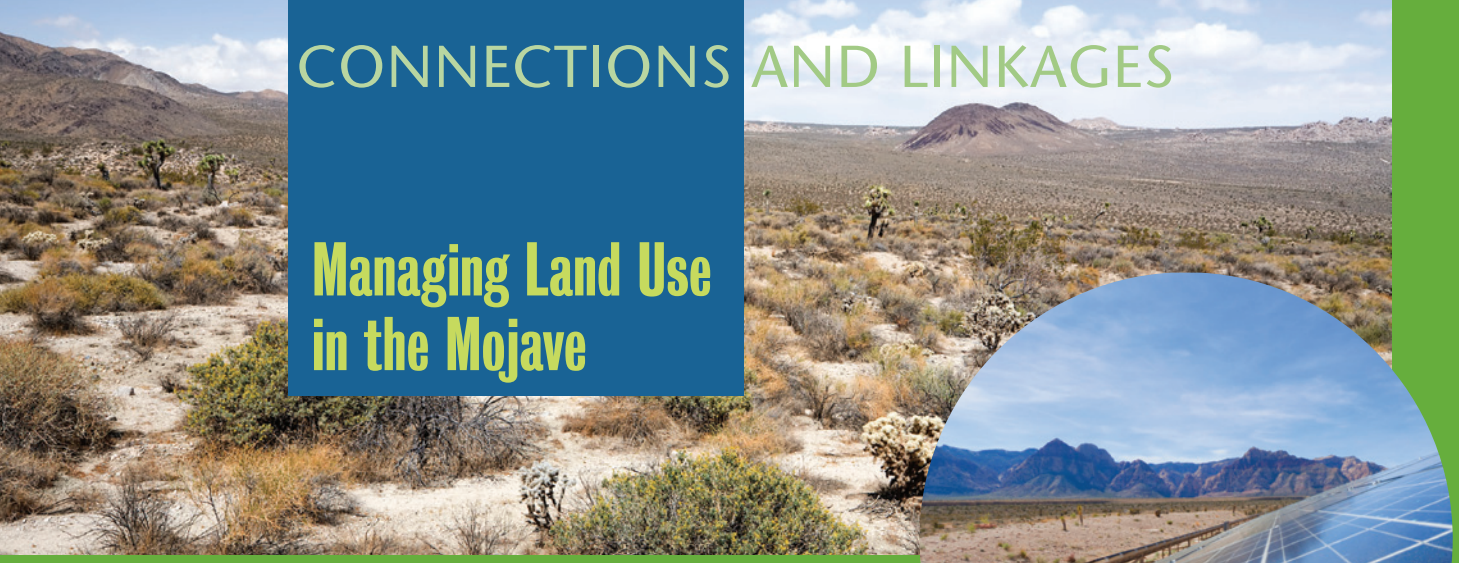
- **Implement the action plan.** In this step, the action plan is implemented. A key component of this step is determining the kinds of boundary organizations or processes that are needed. A boundary organization is one that bridges scientific and technical experts with policy makers and stakeholders. Such organizations often facilitate ongoing dialogue between expert groups and others.

PHASE 3: EVALUATION AND ADAPTATION. This is where short-term outcomes—which occur on the scale of a year to a few years—start to be assessed relative to the baseline established in the first phase. Are the trends that are observed on track with goals? Significant learning typically occurs during this step; the knowledge and experience gained allow modifications to how the problem is framed and to the approach, methods, and design used to solve it. Additional stakeholders may also be identified and engaged at this point.

PHASE 4: LONG-TERM OUTCOMES. Long-term outcomes are on the scale of several years or more, and should closely track the goals. While performance continues to be assessed and adjustments made during this phase, as in the previous one, a point is reached where a formal assessment is needed. Using the outcome measures developed in the second phase, evaluations are conducted to see if short- and long-term outcomes are meeting goals.

When well-executed, this framework will encourage systems thinking, enhance the legitimacy and relevance of government actions, and result in streamlined and more efficient governance. More detail on the framework and its application to sustainability challenges is included in the full report.

Managing Land Use in the Mojave



Although the Mojave Desert in California may at first seem to be a harsh and empty region, in reality it is fragile and teeming with activity. The land is used for recreation, housing, and military training. It has some of the highest-quality solar and wind resources in the nation, making it a premium location for renewable energy development. It is also home to mining, agriculture, and a wide variety of human and natural communities, as well as a number of endangered species.

Disagreements over how to manage the land's many uses emerged after the passage of the California Desert Protection Act of 1994, a law that prompted major transfers of land from the Bureau of Land Management (BLM) to the National Park Service (NPS). Conflicts between the two agencies arose over grazing, desert tortoise recovery, off-road vehicle use, mining, hunting, military overflights, wild horse and burro management, water for wildlife, and development.

To help lessen the potential for conflict and coordinate the management of Mojave lands, the Desert Managers Group was formed late in 1994. The group includes not only BLM and NPS, but also the U.S. Fish and Wildlife Service, California State Parks, and the four military base commands. Regular face-to-face meetings are held to allow members to work as a group, setting goals, addressing cross-boundary issues, and getting to know one another better. It prompts members to think outside their own organizational boundaries and to enlarge the interpretation of their own agency mission to focus on regional sustainability.

Although a successful collaboration, the Desert Managers Group has neither budget nor regulatory authority over land use or other decisions, and so its impact is limited to coordinating voluntary efforts by its members. Its existence, though, has likely benefitted a newer and broader cooperative initiative that does have regulatory power: the Desert Renewable Energy Conservation Plan, which was created in 2008 to manage Mojave lands in ways that protect habitat and species while allowing for renewable energy development. The group that oversees the plan involves many of the same agencies as the Desert Managers Group, as well as a broader group of stakeholders.

Both of these groups are efforts to collaborate across levels of government and agency responsibilities, initiated because complex problems involving energy development, ecosystem conservation, and the public interest could not be solved by a single agency. As the emergence of these collaborations makes clear, reaching sustainability goals requires partnerships that move beyond traditional organizational boundaries.

Additional Recommendations

In addition to developing a national sustainability policy and adopting the decision framework to address high-priority challenges, the federal government can take additional steps to foster linkages among agencies and stakeholders.

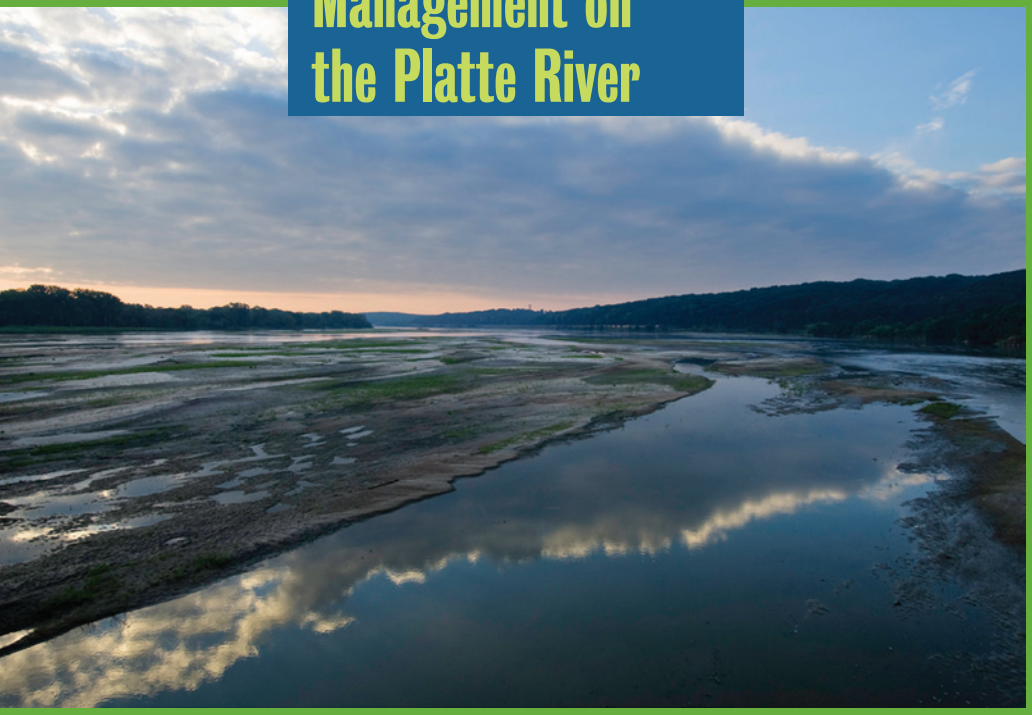
Agencies should support innovations in efforts to address sustainability issues by identifying key administrative, programmatic, funding, and other barriers and by developing ways to reduce these barriers. Agencies need not await structural overhauls to strengthen their capacity to address sustainability issues. They can begin by preparing a high-level systems map that illustrates key connections and linkages, which can then be deployed widely across federal agencies to encourage policy coordination for any sustainability-related program or project.

Agencies should legitimize and reward the activities of individuals who engage in initiatives that "cross silos" in the interest of sustainability, at both the staff and leadership level. Among other things, agencies should develop personnel performance measures that emphasize collaboration and the design and implementation of interagency, integrated approaches to addressing sustainability issues. They should nurture "change agents" both in the field and at regional and national offices, an effort that may include revisions to managers' performance plans, rewards, and training, as well as better alignment of policy tools to support collaboration. Agencies should also enable cross-agency management and funding of linked sustainability activities; in some cases, statutory authority to do so may be required.

Agencies should support long-term, interdisciplinary research underpinning sustainability. Robust research is needed to provide the scientific basis for decision making about sustainability issues. Sustainability challenges play out over long time scales; therefore, agencies should invest in long-term research projects on time scales of decades to provide the necessary fundamental scientific understanding of these challenges.

Agencies that support scientific research should be incentivized to collaborate on sustained, cross-agency research. Sustainability should be supported by a broader spectrum of federal agencies, and additional federal partners should become engaged in science for sustainability. Federal agencies should collaborate in designing and implementing cross-agency research portfolios to better leverage funding.

Adaptive Management on the Platte River



As the Platte River makes its way through three states—Nebraska, Colorado, and Wyoming—it irrigates 2.8 million acres of land, generates 400 megawatts of electric power, provides water to 2.5 million people, and supports habitat for a wide range of wildlife. Balancing these varied demands has not always been easy, especially when the prospect of enforcing the Endangered Species Act along the river raised concerns that maintaining enough water for bird and fish habitats would leave farmers without enough water for irrigation.

After a decade of negotiations, in 2007 the Platte River Recovery Implementation Program was begun. The program sets forth provisions for implementing parts of a recovery plan for four endangered or threatened species along the river in a context where water is also needed for agriculture.

The Governance Committee that is responsible for implementing the program has 10 members, representing a variety of stakeholders—the three watershed states, two federal agencies (Fish and Wildlife Service and Bureau of Reclamation), water users from each state, and two environmental organizations. Nine out of 10 members have to concur on any major policy decision. The Governance Committee contracted with a private natural resources consulting firm, Headwaters Corporation, to provide ongoing program management, offering the benefit of a neutral entity to assist in cross-agency coordination.

Because there are many scientific uncertainties about the magnitude, timing, and temperature of water flows needed to support the endangered species, a key component of the program is an Adaptive Management Plan. This approach allows program managers to test hypotheses about the types of strategies that will work best, monitor for improvements in the river and the status of the species, and adjust strategies as needed. An Independent Scientific Advisory Committee offers guidance to the Governance Committee and the consulting firm as they implement the Adaptive Management Plan.

This cooperative effort has been successful largely because the Fish and Wildlife Service was willing to be part of a neutral authority, the Governance Committee, that included other stakeholders. This neutral authority was able to obtain agreement on common goals and on using an approach, adaptive management, that allows strategies for meeting the goals to be adjusted and improved over time.

Conclusion

Moving forward, it will be important for agencies to build sustainability into their very fabric: their mission statements, their goals and objectives, and their organizational and management structures. But agencies need not await structural overhauls in order to strengthen their capacity to build sustainability linkages.

The sustainability of the nation's interconnected environmental, economic, and social systems, which is vital to the United States over the long term, cannot afford to be constrained by fragmentation of authority, inadequate sharing of information, or the structure of government. Fortunately, there are ways to surmount these barriers and build linkages that will allow agencies and other stakeholders to effectively address sustainability challenges. A National Sustainability Policy would help to break down these barriers by facilitating sustainability initiatives that cut across jurisdictions and resource areas while establishing the fundamental principle of promoting the long-term sustainability of the nation.

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Copies of *Sustainability for the Nation: Resource Connections and Governance Linkages* are available from the National Academies Press; call (800) 624-6242 or (202) 334-3313 or visit the NAP web site at www.nap.edu. For more information on the project, contact staff at (202) 334-2143 or visit the Science and Technology for Sustainability Program's web site at nas.edu/sustainability.

PHOTO CREDITS

Page 2: Alki Beach, West Seattle; Getty Images/Aaron McCoy. **Page 4**: Photo courtesy Agricultural Research Service/Jack Dykinga. **Page 5** (*top*): Summer houses in Scituate, Mass., await the tidal surge from Hurricane Sandy on Oct. 29, 2012; photo courtesy FEMA/Marilee Caliendo. **Page 5** (*bottom*): Biker riding in park with trees and Cleveland skyline in background; iStockphoto © Stewart Behra. **Page 6** (*top*): Philadelphia skyline and Schuylkill River; iStockphoto © Jeff Biglan. **Page 6** (*inset*): Green roof 10 weeks after planting, Philadelphia; photo courtesy Green Roof Works LLC. **Page 7**: Severe soil erosion in a wheat field near Washington State University; photo courtesy Agricultural Research Service/Jack Dykinga. **Page 8**: Satellite image of the Great Lakes; NASA/Jeff Schmaltz, MODIS Rapid Response Team, NASA/GSFC. **Page 12** (*top*): View of the Mojave Desert from Geology Tour Road, Joshua Tree National Park, California; iStockphoto © Steve Geer. **Page 12** (*inset*): Solar Panels in the Mojave Desert; iStockphoto © Andrei Orlov. **Page 13**: Research at the Joint Bioenergy Institute, a new center led by Lawrence Berkeley National Laboratory, University of California campuses in Berkeley and Davis, and Stanford University; photo courtesy DOE. **Page 14**: Lower Platte River, Nebraska; Michael Forsberg Photography. **Page 15**: Flying Great Blue Heron; iStockphoto © photoL.

SCIENCE AND TECHNOLOGY FOR SUSTAINABILITY PROGRAM

The long-term goal of the National Academies' Science and Technology for Sustainability (STS) Program is to contribute to sustainable improvements in human well-being by creating and strengthening the strategic connections between scientific research, technological development, and decision-making. The program examines issues at the intersection of the three sustainability pillars—social, economic, and environmental—and aims to strengthen science for decision-making related to sustainability. The program concentrates on activities that are crosscutting in nature; require expertise from multiple disciplines; are important in both the United States and internationally; and engage multiple sectors, including academia, government, industry, and non-governmental organizations. The program's focus is on sustainability issues that have science and technology at their core, particularly those that would benefit substantially from more effective applications of science and technology.

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