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Building Bridges: Community-Based Social Networks for Sustainable and Secure Water Management

Stephen P. Gasteyer

Rural Community Assistance Program, Inc.

In the wake of the terrorist attacks of September 11, 2001, the U.S. government has developed initiatives to better ensure and assess the security of U.S. water systems. It is telling that the water infrastructure security program at Sandia National Laboratories, one of the key contractors for infrastructure security design and training, is part of Sandia's Water Safety, Security, and Sustainability Initiative. As the quotation below notes, security must be defined in terms of the health of natural resources as well protection from intrusion.

> National and international security challenges have shifted since the end of the cold war. Scarcity of arable land, water, and other basic resources is recognized as a critical component of regional security in many areas around the world. Water resources and the associated supply, treatment, and distribution infrastructures are important elements of national security and face a spectrum of threats. [T]he nation is so dependent on our [water] infrastructures that we must view them through a national security lens. (Sandia National Laboratories 2003)

The point is that water resources security and sustainability should be thought of in tandem. Water that is safe from terrorist attack but either vulnerable to contamination from industrial, agricultural, or domestic pollutants or unavailable due to misuse or mismanagement is equally a threat to public health and safety. The quest for security of water systems, however, may undermine the potential for community-level water resources sustainability if it is premised on limiting information and decision-making authority over water resources to authorized personnel.

This paper will focus on the community aspects of water resources sustainability and water infrastructure security. Community-level consideration of these issues must involve consideration of infrastructure. Infrastructure, after all, is that which moves water to and from its source and makes treatment possible to ensure that safe water is available to humans for various purposes. Infrastructure should also allow water used by humans to return to water sources (e.g., rivers, streams, aquifers) in a form that is usable for natural, as well as social and economic, processes. Infrastructure, when considered in the context of sustainability, is neither purely physical nor mechanical. Indeed, a community of people interacts with water resources through a combination of physical and social infrastructure.

Physical infrastructure may be "built" (using non-natural processes), or "green" (utilizing natural processes). It involves amendments to the physical surroundings and landscape to serve a given purpose—such as transportation; supply of electricity; or water supply, management, and treatment. Social infrastructure may be inclusive (i.e., involving a diverse set of stakeholders) or exclusive (i.e., involving a small group of elites). It is the networks and interactions among individuals, groups, and institutions within and outside the community. Community water system sustainability is determined by the relationship among social and physical infrastructure (Figure 1).

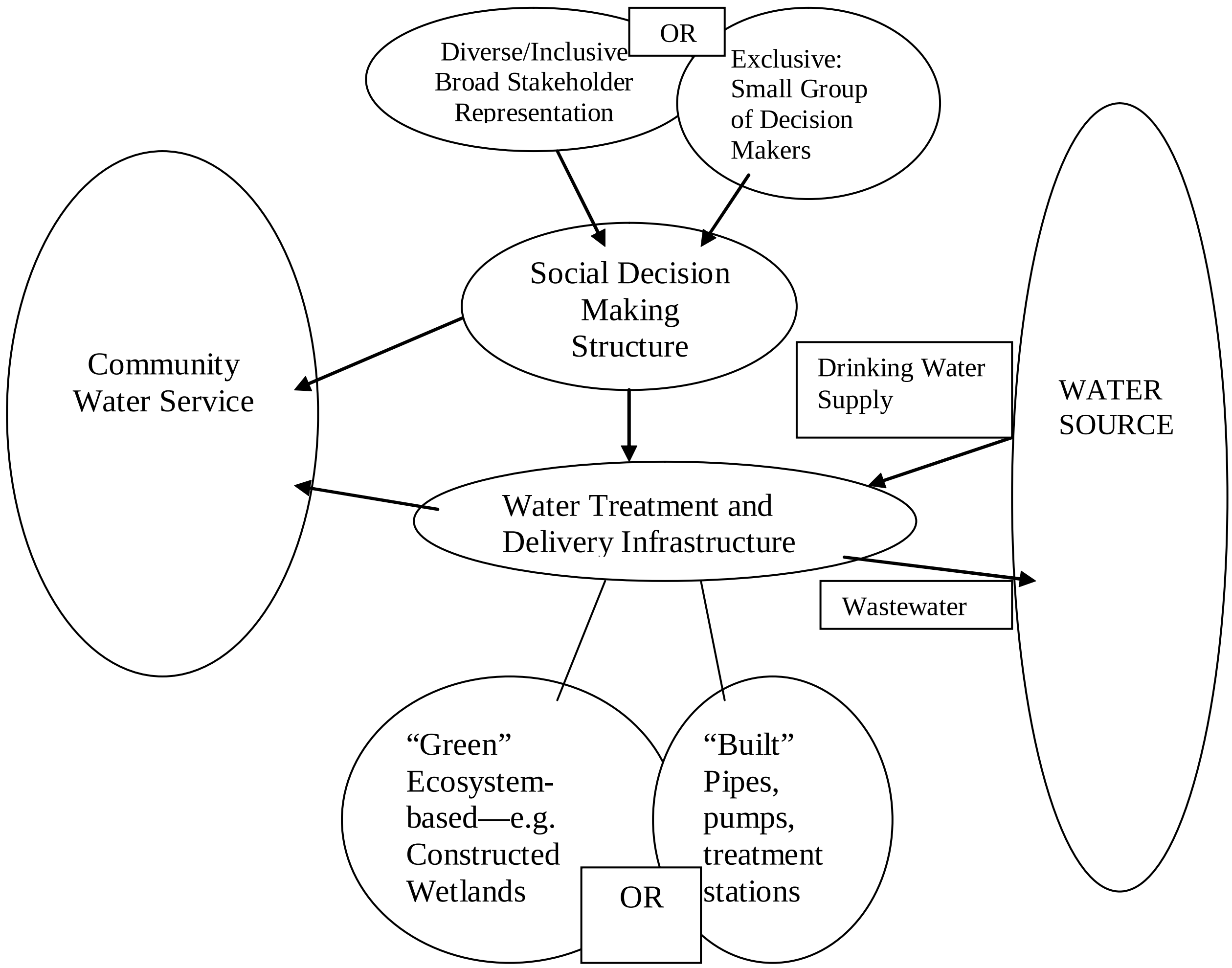

Figure 1. Components of Community Water System to Determine Sustainability

This paper addresses the relationship between social and physical infrastructure in water resources security and sustainability by looking at community capitals (Figure 2). The paper will draw on relevant literature and concrete case studies from U.S. rural communities to exemplify the relationships among community capitals. The paper will also refer to several U.S. government initiatives aimed at improving water system sustainability and security. In particular, I will spell out the danger that these programs may be working at cross-purposes and undermining progress made toward sustainability by privileging built physical and exclusive social infrastructure and economic capital over other forms of capital.

Background

In the wake of September 11, 2001, the U.S. Government has numerous new initiatives to improve security in the water arena alone. Most of these initiatives conceive of security as a matter of technical security resources—locks, alarm systems, fences, doors, armed guards, security inspectors—and communication links among water operators and security officials. In major metropolitan areas, the emphasis on safety and security has indeed been on making our water systems less accessible to intruders. For instance, the Sandia Labs RAM-W process focuses largely on infrastructure solutions for securing U.S. water systems—such as emphasizing eye retina devices to make sure intruders do not enter treatment facilities (Scharfenaker 2002).

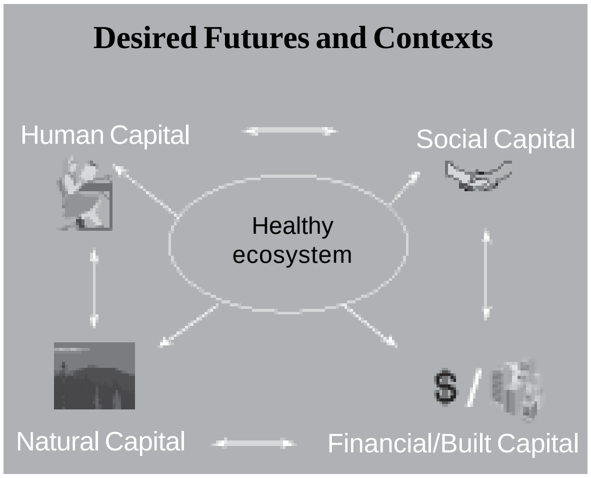

Figure 2. Interaction of Community Capitals in Water Resources Sustainability

As a matter of logistics, this may work for urban water systems, where utilities have the customer base and distribution network to spread the cost. In rural areas, especially in low-income rural communities, large investment in infrastructure is less likely. Many of the 54,000 small water systems in the United States simply lack the available revenue reserves to pay for this kind of system (EPA 2002).

Security in rural communities in the United States has traditionally relied more on social infrastructure (social capital) than physical and policing infrastructure to protect, maintain, and enhance assets (Flora 2002). A key to successful rural community infrastructure systems has been that these systems represent a community-level investment. Not only has the community provided resources for installing and managing the water system, but this investment has usually been accomplished through the development of relationships and social organizational structures (social infrastructure) as well as the physical infrastructure to manage and expand water systems (Warner and Dajani 1973; Butcher 1974).

Sustainable community water management is also critically dependent on the development of a social infrastructure. Water systems are dynamic and change over time in reaction to changes in natural, economic, and social systems. Take, for instance, southwestern Florida. Changes in the Everglades caused by draining and clearing of land—first for agricultural production and later for housing and commercial development—has led to changes in the level and quality of both surface and ground water. These shifts have, in turn, impacted the availability of potable water for people living in that area and have endangered flora and fauna. Solutions based solely on a physical infrastructure model arguably exacerbated the water problems, and it has only been through an extensive stakeholder process that a viable program for ecosystem restoration—and through that improvement in water quality and availability—has emerged in the Everglades region (Hollings et al. 2002).

Especially in small community water and sanitation systems, safety and security is ultimately about building a social infrastructure that will monitor the water system to ensure its safety, assure that development pressures do not contaminate or overdraw on the water source, and take action to mitigate other potential problems. Small communities quite simply lack the financial resources to pay for expensive tools designed to restrict water system access to authorized personnel. Rather, communities need to build the social infrastructure that can replace retina scanners with concerned citizens watching out for the wellhead. Access to information and social process will be critical to making this happen. Sadly, interpretation of the new security mandates may be leading society in the precisely the wrong direction—limiting information that can be a key component in organization around water issues.

By building the social networks that draw on local knowledge of the surrounding ecological and environmental, cultural, and economic contexts, rural communities could recognize and adapt to changes. Improving capacity for disaster response involves enhancing the networks that connect communities at regional, state, or watershed levels. These strategies are equally applicable to attempts at improving water sustainability through building systems for water management capacity (Roseland 1996).

Sustainable and Secure Water Systems and Communities: A Model

Community-based sustainable water resources management is about balancing economic and social desired uses of water resources while preserving sufficient water quality and quantity for natural ecosystem processes (Roseland 1996). This statement is simple enough, and it builds on the principles outlined by Krantz, et al. (this volume) in their discussion of a conceptual framework for water resources sustainability.

Balancing economic and social desired uses of water implies not only weighing human and environmental needs but also balancing the water needs for economic and other purposes among different social groups. In other words, sustainability must involve equitable and just distribution of water resources as well as the costs of securing those resources. Simply put, when groups in society are denied access to needed water supplies, the situation is not sustainable (Roseland 1996).

At the same time, a right to water implies a right to participate in decision making about how water is to be allocated and treated. The development of water resources from the late 1800s through the 1970s was often carried out by centralized government authorities charged with managing these resources. From mismanagement of water resources in regulated waterways of the western United States to failing irrigation systems in Pakistan, there is sufficient evidence that top-down management approaches have failed to ensure water sustainability (Postel 1992). Through the 1980s and 1990s, an increasing body of literature has demonstrated the need for public participation and multi-stakeholder approaches to water management (Ostrom 1996).

Defining Sustainable Water Management at the Community Level

Scholars of community sustainability use indicators of human, social, built/financial, and natural capital to understand the dynamics of sustainable water resources management at the community level (Flora 2000). Social infrastructure in water resources management involves a combination of human capital and social capital. Human capital refers to skill levels and abilities—such as the average level of education in a given community, or the number of people per 100,000 with cancer. Social capital refers to the networks and trust that exist both within and outside the community, such as the number of organizations, the level of participation in community events or the range and number of community members involved in decision making. It also refers to linkages of community groups to other groups outside the community. A critical distinction should be made between within-group ties (i.e., bonding social capital), which often characterize insular communities or groups, and bridging social capital, where strong networks are established with outside groups or institutions. Built/financial capital refers to a community's financial resources and infrastructure—both average income and number of roads into and out of the community. Natural capital refers to the natural resources and attributes of the given community—such as forest or fish in a stream (Gasteyer et al. 2002).

These capitals provide key categories for indicators to assess water sustainability at the community level. An implicit assumption is that a key component of community-level water resources sustainability is the ability of the community to engage in constant innovation as the ecosystem changes around them (Kemp-Rye 2003). In other words, indicators of water sustainability in the community context must measure community skills, conditions, and networks as well as physical infrastructure and environmental conditions.

Very often, community-level development focuses on various forms of industrial recruitment, without adequate attention to natural or social capital. Emphasis is on human capital development (e.g., training and jobs), and financial and built capital such as short-term growth in aggregated financial resources (GDP) and existing infrastructure and financial assets. Conversely, traditional environmentalists are often accused of focusing on natural capital, such as endangered species preservation, to the exclusion of other capitals. Neither path is sustainable. Community leaders are increasingly recognizing the linkage between quality of life and enhancing natural capital and social capital, as well as financial and human capitals (Kinsley 2002). Environmentalists are beginning to recognize that programs to enhance natural capital, such as to improve water quality or biodiversity at the community level must be accompanied by initiatives that maintain or enhance social and economic capital (Barnard and Young 1997).

A key to achieving this balance is recognition that physical infrastructure may only enhance financial and built capital, or may be designed to enhance natural and social capital. In short, the infrastructure may be "manufactured" or "green." For instance, in the wake of the 1993 floods in Iowa, many communities attempted to prevent future flooding by hiring an engineering firm to build higher dykes and levees. This manufactured solution that was financial and built capital intensive did little to enhance social capital, and disregarded the potential role of natural capital in finding a solution.

There were some communities, however, that recognized the possibility of utilizing natural capital to develop a more sustainable solution to flooding. Rather than rebuilding those homes that had been in the flood plain, they used Federal Emergency Management Agency (FEMA) money both to help the displaced homeowners resettle in upland areas and to convert the floodplain back into natural wetland buffers. The communities often installed parks and trails, bringing together people from the local community to experience the natural habitat of prairie marshland, including native grasses, birds, insects, and prairie flowers, among other things. Utilizing a green infrastructure approach enhanced natural capital and social capital while sustainably solving the flooding problem (Wagner 1996). Many of those communities who put in the concrete flood control devices found themselves appealing to FEMA for aid soon afterwards, as Iowa suffered three more “100 year” floods during the 1990s.

Likewise, community wastewater problems could be addressed through conventional water treatment approaches or alternative natural systems. Using the conventional approach, wastewaster is directed from homes and businesses into a treatment plant, where it is treated with an aeration or similar system, and released into a neighboring stream or river.

Alternatives do exist, however, for enhancing natural capital with a constructed wetland, which may have the benefits of allowing for native grass regeneration, and providing a habitat for other species. It would also be possible to put in a decentralized wastewater treatment program—that would be managed through a system that is social capital intensive. Community institutions are established to monitor septic performance throughout town, and educational campaigns ensure that homeowners and renters understand the responsibilities of septic system management. An example is the small community of Spring Hill, Minnesota, where the community worked with an intermediary NGO to get the approval from the state clean water regulator and funding from the Federal government for a constructed wetland to manage a wastewater issue. The program for monitoring the wetland involved multiple community members. More importantly, the wetland used native plants to treat the wastewater, which has attracted visitors from throughout the county to admire the system, increaing community pride (Miersch 2001).

Community Level Water Sustainability and Security

In terms of security, while prevention is important, it is arguably more important to think about how communities will respond to a potential crisis. The reality is that while the Department of Homeland Security identifies water infrastructure as being at high-risk for future attacks by terrorists, it is not likely that these attacks will be in small town America.[1]

Small community water systems are, however, at risk from vandalism, either from disgruntled customers or employees or drunken high school students, or from natural disasters such as tornados or hurricanes (Sandia 2003). Water system security, thus, should involve some level of investment in built/ financial capital to provide a hindrance to potential intruders and vandals. In many communities, far from investment in retina scanners and computerized “SCADA systems” to monitor system infrastructure, this investment may be as rudimentary as placing a padlock on the door of the water storage tank and treatment house.

The U.S. Environmental Protection Agency (EPA) has required all water systems to develop vulnerability assessments (VA) and emergency response plans (ERP). For larger water systems, the EPA requires that these assessments be submitted to the agency. For small water systems, while they do not require that VAs be submitted to the agency, they do require that small systems (mostly in rural communities) carry out the VAs. EPA has funded small system technical assistance organizations to educate trainers who will teach small-system operators to develop these assessments and plans (Copeland 2003).

As it turns out, many of the components of the VAs are already covered under the requirement for water systems to carry out the required “sanitary surveys” to ensure that drinking water systems are in good working order and treating water to adequate quality (EPA 1999). The 1996 Amendments to the Safe Drinking Water Act established standards for small drinking water system technical, managerial, and financial capacity and authorized and appropriated funding for small water system capacity development—including the training of water operators and management boards. Agency documents paint the capacity development program as enhancing human capital by operator training and physical and financial capital through ensuring that appropriate infrastructure and treatment facilities are in place (EPA 2003). Technical assistance providers working with water systems often argue, however, that capacity development should also enhance social capital—through the building of social networks to ensure community water systems have the capacity to respond to unexpected events. From the community perspective, this is a critical component of water resource sustainability.[2]

Social networks with people who can provide various resources in the eventuality of such an event are essential to responding and minimizing harm to the community. These networks should be built within (known as bonding social capital) and outside the community (known as bridging social capital), setting up systems of preparedness at multiple levels. By building bonding social capital, water officials can engage the local volunteer fire department, health clinic, police department, and community charitable organizations and businesses both to provide service to community members lacking water service and to restore lost water service. These same officials will also need to build bridging social capital to create relationships with county and state emergency response officials and neighboring communities who can provide key back-up water services among other things. Bridging social capital also implies acceptance of diversity and alternative approaches, which will be a critical component of a community's ability to continuously adapt to, analyze, and predict changing environmental conditions.

Water officials must also work with residents to help the community prepare to respond to a crisis that may strike the water system. What will be the channels of communication to residents? Where will information be available to let residents know about water quality and how to react? What kinds of backup water supplies should residents have on hand? Innes and Booher (1999) describe how multiple forms of communication and interaction prepared citizens to react in response to the eventuality of an earthquake in Santa Barbara, California. This same principle applies to preparation for a disaster that involves the community water system.

The 1996 Safe Drinking Water Act also developed a program to encourage source water protection. Many of the initiatives from that program aimed to provide information to citizens to encourage their confidence and participation in water quality protection. By providing information to citizens, the authors of the law hoped to foster community action that would protect water quality. It is arguable that community and water system capacity for water resources management is dependent on citizens having the information necessary to act—though explicit action is also needed to mobilize citizens. Some have interpreted the Biosecurity and Counter-terrorism Act of 2002 to restrict significantly the amount of information that would be made available to citizens. In some cases, this has resulted in citizens not having access to information they need for planning and zoning decisions (Gasteyer 2003).

From a community perspective, water system sustainability and security are related to a balance of community capitals. Water system sustainability is dependent on balancing current development needs (i.e., financial capital) with future needs, which are dependent on ecosystem integrity (i.e, natural capital). In many cases, the concern about natural capital will fulfill part of the need to consider maintenance and enhancement of cultural considerations and local knowledge—human and social capital. These considerations are intrinsically tied to the need to build community capacity for making decisions taking actions at the community level that will maintain or enhance water quality, quantity, and ecosystem integrity. This capacity may be measured by evaluating both levels of human capital involved in operating and making decisions about the water system, and social capital, in the number of institutions, organizations, and social networks involved in water issues and the quality of their interactions.

Indicators of Sustainable and Secure Community Water Resources

Water resources sustainability at the community level is multifaceted and complex. It is about a balance between human, social, financial/built, and natural capitals. For communities, it is important to emphasize the cultural, economic, and intrinsic values (natural capital) that water resources represent.

1. Human capital: Increased use of the skills, knowledge and ability of local people;
   a) Increased number of community members involved in monitoring and evaluation

2. Social capital: Strengthened relationships and communication;
   a) Improved diversity and representation in community decision making about water resources—community sectors represented on community water board
   b) Increased number of groups involved in the initiative—count of type of groups and activity in the water sector

3. Social capital: Improved community initiative, responsibility and adaptability;
   a) Increased political support for water quality protection—Community support for water conservation efforts

4. Natural Capital: Sustainable, healthy ecosystems with multiple community benefits;
   a) Improved water quality—decreasing turbidity over time; decreasing BOD level; deceased nutrient load
   b) Improved water availability—decreased variation in water levels over time
   c) Improved ecosystem function—increased fish stocks; increased birds measured through Audubon song bird counts
   d) Activities and practices adopted to improve water quality—number of acres of vegetative buffers installed

5. Financial/built capital: Appropriately diverse and healthy economies.
   a) Increased local funding of the initiative
   b) Improved integration of water quality and economics
   c) Dollars leveraged for infrastructure improvements
   d) Improved accounting for infrastructure depreciation and replacement

Figure 3. Indicators and Measures of Water Resources Sustainability and Security

Water sources provide wildlife habitat, recreation areas, and basins for spiritual cleansing. At the same time, the use of water for drinking, irrigation, energy, and waste removal involves a linkage between water and infrastructure. Infrastructure, in turn, is created through a nexus between financial/built capital resources (e.g., money and concrete), human capital (e.g., construction, management, and operations skills and knowledge), and social capital (e.g., networks between local groups, state primacy agencies, federal funding agencies and engineering firms), to move water from its natural location to the community and back again. At the community level, sustainability must deal with issues such as changes in water quality over time, planning and zoning to protect water quality and aquatic ecosystems, water infrastructure depreciation, affordability of water and sanitation services, and the water decision making structure.

It is fitting that there are two definitions of security in conventional parlance. Water security is often referred to as securing adequate water resources for human needs—not indifferent from the notion of food security. This definition fits well with the notion of water resources sustainability. The second definition, much more in vogue since September 11, 2003, refers to safeguarding water infrastructure from natural or human caused disaster. If treated holistically a discussion of water security using the second definition can also address issues of water resources sustainability. The discussion, however, must move beyond superior infrastructure to detect “compromises” of the water infrastructure system by unauthorized parties. It must deal, instead, with multi-faceted risk analysis, and the creation of diverse networks (social capital) for emergency response.

Ideally, indicators of community level water sustainability and security would be addressed simultaneously. Figure 3 demonstrates these potential indicators and measures using the community capitals mentioned above. With information coming from measurement of these and other indicators, informed citizens can act as stakeholders and play an essential role in the constant adaptation necessary to balance economic growth, social welfare, and ecosystem integrity (including water quality). Intermediary organizations may likewise play a critical role of helping communities to interpret indicators, plan, and create networks to leverage resources for implementing actions.

Mount Vernon, Oregon provides an example of this tradeoff, as described below.

> Faced with periodic drought conditions that threatened the livability of the community, the community worked with the Oregon Rural Community Assistance Corporation (RCAC) to develop a plan for addressing the conditions in a way that would maintain quality of life. The water conservation management plan identifies characteristics of groundwater and surface water hydrology for the waterways, including Beech Creek, and the mainstem of the John Day River. The plan also identifies geologic characteristics for the John Day Valley with soils and drainage information. RCAC helped city staff draft these sections, and provided feedback on the format based on the new guidelines for the water conservation management plans. A better understanding of the local upper John Day River watershed dynamics has been a result.
>
> The water conservation management plan includes a component of community education regarding drinking water, water use, and costs for the system. The city has been working on educating the public on drinking water, as well as wastewater, systems during the past two years. It is clear that the community has a better understanding of maintaining the systems, as there has been no voiced opposition to slight rate adjustments for infrastructure the past three years. The plan includes information on water use during winter and summer months, and targets the high use months for outreach and education regarding water use, particularly for farming and gardening.
>
> RCAC worked with the finance committee on the budgeting and rate setting process this year. Mt. Vernon's efforts to complete a water conservation management plan using the new guidelines by the State of Oregon, League of Oregon Cities, and Oregon Association of Water Utilities can be a model in the state. Mt. Vernon has gained recognition for its leadership with the Mayor of Mt. Vernon receiving the Oregon Mayor's Leadership Award this year from the Oregon Mayor's Association. Mayor Dennis Bradley stated that one of the most significant changes to benefit the community has been the successful completion of the drinking water system project. The school is interested in environmental education to promote awareness of waterways, water quality, and habitat of Beech Creek and the John Day River. (RCAP 2003)

We see here the nexus at the community level among the community capitals, as financial capital is enhanced through an investment in community organization (social capital), to build human capital (knowledge and skills), to better manage water resources (natural capital). Achieving this balance provides for water resources sustainability, as the community improves management and begins to implement water conservation. This, in turn, improves water system security, as the community is more prepared to respond to the next water crisis (most likely in the form of drought). The infrastructure for addressing chronic water shortage is a combination of social and physical, green and built. Through developing appropriate networks, the community is able to address water security and sustainability issues.

Author Information

Stephen Gasteyer is the director of Water and Community Programs at RCAP, Inc. in Washington, DC. He is responsible for research and analysis of the water, technical assistance, and community capacity development programs, and networking related to the implementation and policy issues related to these programs. He has written extensively and made presentations on community participation and action, water infrastructure development and community organization and water issues, including water privatization, and water governance and management in the US, OECD, and developing countries. He has a Ph.D. in Sociology from Iowa State University. He may be reached at Stephen Gasteyer, PhD, Rural Community Assistance Program, Inc., 1522 K St, NW #400, Washington, DC 20005, Tel: 202-408-1273, ext. 103, Fax: 202-408-8165, email: sgasteyer@rcap.org

Notes

[1] It is notable that this opinion has been expressed by technical assistance providers working with small systems, as well as by community officials (town mayors), who are pleased to have help in preparing for other kinds of disasters, but are skeptical of attack by terrorists.

[2] Personal communications with technical assistance providers and project managers of the Rural Community Assistance Program, a national partnership of non-government organizations that aid low-income rural communities with water and other basic infrastructure. (See www.rcap.org.)

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