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# Sustainability Criteria for Water Resource Systems

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# 1 Introduction

## SUSTAINABILITY: A UNIFYING HOLISTIC FOCUS

When the history of natural resource management during the last quarter of the 20th century is written, *sustainability* may well prove to be the major unifying concept that was advanced, discussed, promoted and accepted, even at the highest levels of government throughout most of the world. This is rather amazing, given the fact that as yet there is no consensus on its precise meaning or even how to measure it. The Brundtland Commission's report *Our Common Future* (WCED, 1987) promotes the all-encompassing concept of *sustainable development*. To quote:

> Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.

In fact, achieving sustainable development that *meets the needs of the present without compromising the ability of future generations to meet their own needs* may never be realized, or even adequately quantified, but it is clearly a goal worthy of serious consideration.

The concept of sustainable resource use has been around for some time. Watershed and groundwater managers had been taught the principles of sustained yield management long before such publications as *Limits to Growth* (Meadows *et al*., 1974) or *Our Common Future* (WCED, 1987). Farmers, fishermen and foresters have concerned themselves for some time now with how to achieve sustainable yields of food, fish and fiber, respectively, from a given area or region. The current concept of sustainable development, however, is much broader in scope than the term *sustained resource use* or *yield management* (see, for example, Biswas, Jellali & Stout, 1993; Brooks, 1992; Brown, 1991; Goodland, Daly & El Serafy, 1991; Pearce & Warford, 1993; Plate, 1992; and Svedin, 1988). Today sustainable development refers to a process in which the economy, environment and ecosystem of a region develop in harmony and in a way that will improve over time. It is a concept so broad that it seems to defy a precise quantitative definition – a definition that anyone can use to measure the relative degree to which some action or policy contributes to a sustainable improvement in social welfare.

Historians reporting on the events of this last quarter century may show that the real value of books like *Limits to Growth* and *Our Common Future*, and conferences like the UN Conference on the Human Environment held in Stockholm in 1972, and the UN Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992, was not that they led to specific actions that turned out to have saved our planet. Their value may well be that they changed the way many viewed the environment and ecosystems as they worked to advance economic development and equity. We may look back to this last quarter century as a time when many changed their way of making decisions and began doing things in a manner that recognized, and was more compatible with, environmental resource realities and limits.

Perhaps what has pushed the concept of sustainability into the public's conscience more than any other factor is a growing awareness of the global scale of many environmental impacts associated with our economic development activities. What people do to the rain-forests of Brazil or Cambodia can affect those living in China and North America, and indeed, the consumption of coal, oil and wood for energy in China and North America will influence

the decisions of resource managers living in Brazil and Cambodia. While some debate is still taking place regarding the extent of any global impacts associated with specific economic development activities, we know, and can easily document, the extent of various detrimental environmental impacts over large regions. People in stressed regions are justifiably concerned, especially those who have few if any choices as they strive to support their families. All of us are together on this planet, and the planet is not getting any bigger. It is thus incumbent upon us to manage our resources more effectively to permit continued development in this finite world – development not necessarily of more material goods, but of a higher quality of life for everyone.

The Brundtland Commission argued that economic development and the maintenance of a high quality environment need not be in conflict, provided humanity ensures that such economic development is sustainable. As stated by Bruce (1992):

> First, development must not damage or destroy the basic life support system of our planet earth: the air, the water and the soil, and the biological systems. Second, development must be economically sustainable to provide a continuous flow of goods and services derived from the Earth's natural resources, and thirdly it requires sustainable social systems, at international, national, local and family levels, to ensure the equitable distribution of the benefits of the goods and services produced, and of sustained life supporting systems.

The Brundtland Commission identified a direction for development and a road map to an acceptable future. Their report and a series of preparatory meetings ultimately lead to the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in June 1992. Sustainability, as discussed in that conference, has since became a household word, at least among those addressing both development and environment at the national and international levels. The development and management of water resource systems is a key part of sustainable development. Sustainable development cannot succeed without sustainable water resource systems supporting that development. While the UNCED conference, and all the preparatory conferences and meetings leading up to the UNCED conference, identified some broad guidelines and principles for water resources development and management, they did not define or translate these broad guidelines into specific concepts that can be applied to the designing, operating and maintaining of water resources and water projects in specific regions. The details of how water resources systems should be developed and managed so as to contribute to the fullest extent possible to sustainable economic and social development in specific regions can only be worked out by all interested and impacted stakeholders in those regions. Documents resulting from various national or international conferences and meetings, and even working groups or committees such as this monograph, can only provide some assistance and guidance to those who are actually involved in planning and decision-making in specific regions.

There now exists a well-stocked bag of tools available for studying and analyzing problems of supply and demand and for planning, designing and operating facilities that meet the demands for water of sufficient quantity and quality at reasonable costs. Research and the collective experience of generations of water engineers have provided professionals with many of the requisite methods. However, over time, conditions and objectives change. Well-established design concepts must be reviewed, revised and adapted to meet current and expected future conditions. New methods must also be developed and tested to meet new objectives and new demands of society. One of these new (or at least renewed) demands is that of achieving sustainability. Meeting sustainability objectives will certainly require an increased understanding of the interactions of nature and society. Even with greater understanding, however, a catalogue of problems arises for which answers must be found. Obtaining those answers will require investments in research and technological development.

A primary consequence of sustainability is that the single- or multiple-purpose project approach must be expanded to one that is more integrated or holistic, multi-disciplinary and regional in its view. The different purposes of water resource development – water supply, water quality, flood control, navigation, recreation, hydropower, etc. – should no longer be considered as merely technical or economic issues that can be examined locally (and separately) by professionals. Water resources problems must not be viewed as purely technical or economic single-purpose and single-project (or even multi-purpose, multi-project) challenges and opportunities. Rather, they must be seen as planning and management activities that are intimately intertwined with broader societal demands and issues. While engineering is needed, engineering itself is only one of many disciplines that must be involved in holistic, integrated and sustainable water resources development and management. Water resource systems must be considered integral parts of a changing societal system. The interactions of the system with society and environment must be taken into account by experts from all appropriate disciplines.

Systems must obviously be designed and managed to meet the current needs or demands of those who use or can benefit from the use of the system. They must also be sufficiently flexible (robust) so that, if required, they can easily adapt to unexpected future changes in demands or purposes. Systems must also be resilient, which implies an ability of structures or institutions, with proper maintenance, to recover and function properly after some unforeseen failure event. A resilient system, if damaged by a rare event, can be reconstructed with a minimum of effort, and at affordable costs.

As valuable and critical as water is for economic development and human health, it is commonly considered a free resource. Water is one of the most essential, and most subsidized, inputs to human activity throughout the world. In the more developed regions, people strive to live where they can find the work and quality of life they want. If the quantity and/or quality of water is insufficient, their public institutions are often expected to, and usually do, provide the needed quantity and quality of water at acceptable (subsidized) costs. From the financial point of view these systems may be unsustainable.

## WHY THIS MONOGRAPH?

Our capacity to move earth, build dams, pump, treat, distribute water, and produce hydropower, has increased over the past century. So has our capacity to manage and control water supplies to meet a multiplicity of purposes and objectives. But this increase in control has been accompanied by increases in economic and environmental costs. The costs of the increased control include those associated with the loss of natural habitats, the increase in threats to supplies from pollutants, the increasing frequency of demand-related droughts, and the mining of groundwater aquifers. As a result, it has become evident that many of our water resource developments and management practices implemented during this past century should be re-examined. We need to be sure that what has been and is now being done with our water and money will result in a sustainable (long-term) improvement in the quality of life for those who are dependent upon that water, now and on into the future.

This monograph addresses the need and challenge to re-examine our approaches to water resources planning and management. If the results are to be sustainable, we need to develop a more holistic and integrated life-cycle approach to water resources planning, development and management. Such an approach should lead to plans, facilities and policies that will be physically, economically, environmentally, ecologically and socially acceptable and beneficial by current as well as future generations. How can this be done? What criteria can guide us toward achieving more sustainable water resources systems? This monograph addresses these questions. While it focuses on the contributions scientists, engineers, economists, planners and other specialists can make, it recognizes that their contributions are not sufficient by themselves. Important contributions to efficient and sustainable water management and use must also come from the public, the stakeholders and their political representatives and institutions.

Most of today's problems can be solved, and in a way that is sustainable. But leadership, together with an appropriate management structure, must exist before this can happen. If specialists in one or more areas of water resources planning and management are to become leaders in this transition to a more sustainable management of natural resources and environment, they must become involved in the political processes that take place in decision-making institutions.

## SOME THINGS TO REMEMBER

- The concept of sustainability has grown in importance because of the growing awareness of the global scale of the environmental impacts of economic development activities.
- There already exists a well-stocked bag of tools available for studying and analyzing problems of supply and demand and for planning, designing and operating facilities.
- The single or multiple project approach must be expanded to one that is more integrated or holistic, multi-disciplinary and regional in its view.
- Water resources problems must not be viewed as purely technical or economic single-purpose or even multi-project challenges and opportunities. Rather, they must be seen as being intimately intertwined with broader societal demands and issues.
- Systems must be designed to be robust and resilient so that they can easily adapt to unexpected future changes and be able to recover and function properly after some unforeseen failure event.
- Even though most of today's problems can be solved in a way that is sustainable, a proper management structure must exist before this can happen.