SUSTAINABLE DEVELOPMENT, WATER RESOURCES, AND DESALINATION

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Summary

Our objectives in this paper have been to illustrate the way in which one specific issue, the need to bring about water resource facilities including desalination facilities, necessarily grows in scope such that it only becomes feasible to consider the engineering and architecting of appropriate systems when the specific issue is imbedded into a wealth of other issues. One of the major issues is that of sustainable development and that is the special focus of this paper. Hopefully, our discussions provide an illustration of the many attributes and needs associated with the important interrelationships between assuring an adequate water supply for humanity and sustainable development.

1. Introduction

Sustainable development refers to the fulfillment of human needs through simultaneous socioeconomic and technological progress and conservation of the Earth's natural systems. Sustainable world progress is dependent upon continued economic, social, cultural, and technological progress. To achieve this, careful attention must also be paid to preservation of the Earth’s natural resources. Sustainable development is a term generally associated with the achievement of increased technoeconomic growth coupled with preservation of the natural capital that is comprised of ecological and natural resources. It requires the development of enlightened institutions and infrastructure and appropriate management of risks, uncertainties, and information and knowledge imperfections to assure intergenerational equity and intragenerational equity, all in support of enhanced human capital and conservation of the ability of Earth’s natural systems to serve humankind. This paper discusses management strategies for sustainability in a broad sense. We specialize some of these discussions to the important area of water resource systems engineering and desalination as technologies in support of enhanced sustainability. These issues are particularly important at this time since water is a vital resource which is necessary for all aspects of human and ecosystem survival and health. New apprehensions have been raised about growing water scarcity and contamination and the likely inability to meet the water requirements of a rapidly growing world population. *Industrial Ecology, Water Resources, and Desalination* by Sage (2000) discusses the use of industrial ecology and systems engineering and management approaches to enhance water resource availability, in large part through desalination.

In his comments introducing the 1995 IDA World Conference, Al Gobaisi (1995) made the following comments: “Desalination processes are presently material and energy intensive. The process wastes are also considerable. At present, the attitude of the desalination community is to aim at a certain amount of production of potable water to satisfy the demand and to tackle the internal problems of the desalination plants such as corrosion by methods based on the narrow perspectives taking into account only local and temporal requirements. We are now poised to enter the twenty-first century in which there exist great challenges. We as a community of engineers, technologists, and managers of desalination plants have to consider the call of the next century for sustainable development which implies economization of material and energy resources utilization and reduction of wastes with a view to conserve the environment. The next century will be an era in which our perspectives should be widened to encompass environmental conservation together with social, industrial, agricultural and economic factors. It is time we recognize the need to cast off our compartmental attitude in our practices and to adopt an integrated approach to desalination. I wish to point out to an important shift that is needed in the current material and energy intensive paradigm of desalination practice. As in any process, materials and energy happen to be the inputs. Desalinated water and waste are the outputs of the process. Another important input is regarded as vital to move towards sustainability. This is a non-material entity of complex nature. Some experts call it information” (p. 1).

This is a very important challenge and there are many important challenges facing the world today. Among these are sustainable development, an effort to ensure continued enhancement of the efficiency, effectiveness, and equity of technoeconomic developmental efforts while at the same time preserving the natural resource base for future generations. There is a myriad of technology and policy attributes and major risks, uncertainties, and information and knowledge imperfections, associated with these issues. We comment on each of needs as we pose the hypothesis that the next generation’s challenges will be integration, process, and systems management challenges associated with the simultaneous management of natural capital and sustainable development. There is a unique role for systems engineering, in the form of a systems ecology (Sage 1998a, b), in enabling the formulation, analysis, and interpretation of these complex contemporary issues of large scale and scope and this role is described in a companion paper. We describe sustainable development principles here, particularly as they relate to water as a life support resource and to desalination for enhanced capability of water resource systems in support of sustainability.

There is a very large variation in per capita water availability for each continent, ranging from 70 000 m^3 per person per year (Oceania) to as low as 7000 (Africa) and 3500 (Asia). There are even greater differences on a national or regional basis, with countries such as Iceland, Canada, New Zealand, and Norway having more than 100 000 m^3 of water per person per year and some countries in Northern Africa and the Middle East with less than 100 m^3 per person per year (Gleik 1993). Per capita water use also varies significantly due to a mix of economic, infrastructure, social, cultural, and physical reasons. North Americans use more than 1600 m^3 of water per person per year, Europeans use 725 m^3 per person per year and Africans use under 250 m^3 per person per year. Larger numbers of people in a given population will reduce the total per capita water availability over time if the amount of water available is limited and there are many studies of regional water availability and water demands under diverse population scenarios (Gleik 1993). Most studies suggest that the number of people in the world with abundant water available is not likely to increase considerably over time in the foreseeable future. Rather, the number of people in the world that are in water-insufficient situations will increase dramatically and between half and two-thirds of the world's population will be under some degree of water stress by the year 2025.

Technological innovations can potentially alter water availability. Essentially unlimited quantities of fresh water are available by using water that is currently trapped in icecaps and glaciers. On a larger scale, mass desalination of seawater could lead to an abundance of fresh water. Pragmatically, increases in overall water availability will occur only in situations where the societal value of water is sufficiently high and where the economic and the ecological costs of acquiring water through new and innovative technologies are sufficiently low. There are many interactions involved in these considerations. Total water availability is and always will be a stochastic process and systems may be developed and deployed to accommodate that stochastic variability. However, there are large changes expected from the greenhouse effect and global climate change which will affect the hydrologic cycle and water availability in potentially unknown ways.

We wish to examine some implications of these foresights here, specifically with respect to the interactions across water needs, economics and policy, and human and social needs as they relate to sustainable development. We first look at the many dimensions of sustainable development. We then examine some needs relative to natural resource sustainability and provide particular emphasis on water needs. We then examine threats to sustainability and needs for sustainability in a much broader context. Information and knowledge needs are manifold relative to achieving sustainable development. The last major section of the paper discusses these.

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