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Water, Environment, Energy, and Society—Interaction and Interdependence

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ABSTRACT: Management of natural resources is inherently complex. People in developing countries live in close proximity to nature and hence changes in environment and climate have a significant influence on their lives. Society is facing grave multiple water-related problems: decreasing per capita accessible water, change in climate, and deterioration of environment and ecosystems. Despite these problems, adequate attention to the eco-friendly management of environment and water resources is still not widely given. To save mankind from serious damage, we need to synergize appropriate technology and spirituality for the management of these resources. Certain religious precepts and traditional wisdom serve as links between society and environment; science and engineering constitute the foundation of these vital links. Indeed these should constitute the fabric of all sections of the society and all nations in order to ensure our common and safe future.

INTRODUCTION

According to Indian scriptures, a human body is made from five elements: soil, water, fire, sky (or ether), and air:

Kshiti (soil), jal (water), pawak (fire), gagan (sky or ether), sameera (air)Panch (five) tatva (elements) se (from) bana (made) sharira (body).

[Indian scriptures]

Each of these elements is associated with a God in India and these elements have therefore been objects of worship, forming an integral part of Indian culture and tradition. Even today millions of Indians worship these Gods daily and all festivities and functions of any significance in the Indian society begin with the worship of these Gods. Making the five elements as part of religious practices or for that matter as part of religion, the primary message was one of protection of these natural elements. Owing to their religious significance, these five elements enjoy a special niche in the Indian society.

Water is vital for the well-being of our civilization and is one of the most precious natural resources that support human life, promote sustainable development, and maintain healthy ecosystems. Sustainable development has to necessarily include protective management of natural resources, economic development by way of energy and food security, eradication of poverty, safeguarding of human health, reduction of child mortality, and promotion of gender equality. Water is central to environment. Its presence and absence can mean life or death, prosperity or poverty; access and control over it can lead to political conflict, social unrest or even war. Figure 1 shows a conceptual view of interaction and interdependence among water, environment, energy and society.

Before the invention of electro-mechanical machines, rivers and lakes were the only sources of freshwater. No doubt that in ancient times, these sources were considered as sacred by millions. Since water treatment techniques were not known, care was taken not to pollute water bodies.

Wise Water Management

At this stage, it is pertinent to ask: How wisely are we using the precious and limited natural freshwater resource? Have we taken good care of our natural resources? Where and how serious is water scarcity? Is there a water crisis? What is the role of water in society? What is its relevance in environmental management? What is the cause of pollution of our natural resources and what could be its consequences?

What should we do in order to leave the natural resources as well as we have inherited them or better? Before attempting to discuss answers to these questions, it will be helpful to review the state of water and environmental resources.

Fig. 1: Interaction and interdependence among water, environment, energy and society

FRESH WATER RESOURCES

Only 2.5 percent of the water supply on earth (1,386 million km^3) is fresh water. Nearly 69 percent of the fresh water is locked in the Antarctica ice Greenland; and the remainder is present as soil moisture, or lies in deep underground aquifers as groundwater not accessible to human use. Less than one per cent of the world's fresh water or about 0.007 (this number, very aptly, is called the James Bond number of hydrology) per cent of all the water on earth is readily available for direct human consumption. Evapotranspiration from non-irrigated cropland is called green water in contrast with blue waters of rivers and aquifers.

Reviewing global hydrological cycles and world water resources, Oki and Kanae (2006) argued that when making assessments of fresh water resources, we should principally consider flows rather than storages. To illustrate, the total amount of water stored in all the rivers of the world is 2,000 km^3, whereas the annual water withdrawal is 3,800 km^3 and the discharge going to oceans and seas is 45,000 km^3/year. Evapotranspiration is approximated to be 7600 km^3/year from cropland and 14,400 km^3/year from permanent grazing land. However, we feel that it would be more insightful to compare the total water availability with demand/withdrawal in each river basin.

International rivers, lakes and aquifers form a major part of the global stock of water. According to the 1999 international registry of the river basins of the world, there are 261 international rivers covering 45.3% of the land surface of the earth, excluding Antarctica, which has a supply of 85% of the world's fresh water. Sixty percent of the world's population lives in the international watercourses and dozens of nations share international rivers, groundwater basins, and coastal waters. Disputes among riparian states over limited shared water resources have already started to occur, and they will likely increase in the future. The existing law on international waterways is one of the most unsettled and weakest areas of international law. However, if the neighboring countries are willing, lasting solutions can be found. For example, the Danube River flows through 18 countries and there is no dispute among these countries regarding sharing of its waters. The global community has an obligation to improve existing laws on international waterways and make acceptable laws regarding ground water in order to develop better ways to deal with international water bodies in terms of water quantity and quality.

Freshwater is a renewable natural resource whose circulation rate is determined by the climate system which puts an upper limit. Oki and Kanae (2006) found the current withdrawals to be well below this limit. The current withdrawal of 3,800 km^3 is less than 10% of the maximum allowable renewable freshwater resources. This means that there is plenty of room to increase withdrawals globally. However, the amount of freshwater available varies greatly both in space and time and depends on climatic variability. In addition to seasonal variability, there is considerable variability from year to year. This variability is even greater for smaller river basins. The spatial distribution of renewable freshwater resources is also uneven. Pronounced variability is the reason that the water of right quality and in adequate quantity is not always available at the right time and at the right place. Storages are the principal means to modulate the effects of seasonal and annual variability. Although thousands of storage facilities have been constructed throughout the world, many rivers are still poorly regulated and creation of new facilities is becoming increasing difficult mainly due to the opposition by environmentalists.

WATER USE

The major consumer of water in the last century was the agricultural sector which consumed more than half of the water used. According to the data given by Biswas (1998), agriculture accounted for nearly 90% of all water use in 1900 but its share has declined to about 62% by the year 2000. This trend is likely to continue into the 21st century. At the beginning of current century, the demand for industrial and urban sectors was about 2500 and 240 km^3 per year; the rural sector required about 135 km^3 water annually. These numbers are likely to change as the estimates are being continuously updated and one may come across different numbers from different sources. The lack of consistent and reliable data on both the supply and the use of freshwater creates serious problems in efforts to manage water resources.

Hydropower is the largest renewable source of energy and is the second largest source of electricity generation. According to the estimates by Water Vision (2000), only about 33% of the economically feasible hydropower potential of the world has been developed so far. There are many 'pockets' of hydropower which are yet to be developed. Keeping in view the technological developments, the cost of hydro-electricity generation in the near future is expected to be in the range 3 to 6 US ¢ per kWh. Furthermore, due to the development of turbines which can efficiently operate at low heads, it may be possible to modify many existing dams which are not presently operated for hydro-electric power and use them to generate power. Electricity generation from fossil and nuclear fuels also requires water for steam, cooling and general services. Besides, in coal fired plants, water is also needed for ash transport.

Water is an important input resource for many industrial activities. The paper industry requires 40–400 m^3 of water per ton of paper, depending on the type of raw material. If a hydraulic method of coal mining is used, about 0.08–0.14 m^3 of water is needed per ton of coal produced. Coal slurry pipelines need 0.95m^3 of water per ton. It is estimated that about 0.163 m^3 of water per barrel (0.159 m^3) is needed to refine crude oil.

The transport of goods by water is highly fuel efficient with insignificant air pollution. The consumption of diesel per ton-km of goods by road is 0.04 liter, by railway 0.011 liter and by water 0.0056 liter. Navigation is not a consumptive use of water; a reservoir downstream of the navigable waterway can capture flows in the waterway and provide them for other beneficial uses.

Water is also required to sustain rivers and wetlands. River restoration has become a topic of interest in some developed countries and such projects can form part of a sustainable development plan for the river basin. The objectives of river restoration are normally to create a wider diversity of ecosystems and improve biodiversity by bringing the river into closer contact with its flood plain. A certain minimum flow is needed in a river to dilute pollution; water also washes away salts that would otherwise destroy farmlands.

Analysis of data indicates that the rate of rise of water use has been about three times higher than the rate of increase in global population. If this figure is extrapolated then doubling the world population would entail a six fold increase in the total global water requirements. Water use data indicate that the Asian continent is the highest consumer of water. This is because Asia has very high population and agriculture, which consumes large amounts of water and is the main occupation of many Asians. Clearly this is not sustainable. Worse, even now, water is treated as a free resource in many countries, although water deficits are being witnessed in many parts of the world. However, as the demand versus availability worsens, it is likely that water prices will also have to be gradually increased, also as a means of controlling demands.

Since an improved lifestyle requires more water, improvement in the standard of living of the people is also responsible for higher water demands. As governments are committed to providing clean drinking water to the entire population, the urban water use is expected to significantly rise by the year 2050 which is the time by which the world population is expected to stabilize. The provision of sufficient water for all the needs will also require substantially higher investments. The reason is that the cost of developing new sources is rapidly increasing due to the higher cost of construction materials, labor, as well as higher provisions for rehabilitation and resettlement of the project-affected people. Environmental laws as well as water quality standards are becoming more and more stringent with time and this will also force agencies to spend higher amounts of money on developing new water resources.

Water Scarcity and Water Crisis

Fresh water resources in the 21st century are under increas-ing pressure. Accelerating demand for water by growing population; expanding urbanization and industrialization; increasing water demands for domestic and industrial water supply and agricultural irrigation; impacts of global climate change, natural disasters and human-induced hazards; increased economic activities;

large-scale changes in land-use and urbanization; contamination of surface and groundwater resources; conflicts over shared water resources; improved standard of living; and the intense competition for water demands are putting unprecedented pressure on the limited fresh water resources. Excessive pumping of aquifers and deteriorating quality of both surface and groundwater supplies are making it difficult to meet increasing water demands. The result is that water scarcity has already reached crisis proportions in many parts of the world and is likely to become even more acute in the foreseeable future. This is particularly the case in developing countries where 95% of the world's new population is born. Water scarcity is a major factor impeding economic and societal development, and is being compounded by contamination of resources.

Scarcity of freshwater due to rising demands and pollution is being compounded by climate change. UN/WWAP (2003) estimated water use for human consumption to have increased six-fold in the 1990s. Projections point to doubling of global water consumption every 20 years, more than twice the rate of increase of human population. In many areas of the world, water withdrawals are so high as compared with supply that surface water supplies are shrinking at an alarming rate and groundwater reserves are being depleted faster than they can be replenished. In India, the number of blocks where groundwater withdrawal was more than recharge was 252 in 1985 and it increased to 445 in 1998. An implication of this scenario is that increasingly higher costs for economic growth and meeting daily human consumption needs will have to be incurred.

Definitely there is a "water crisis" in some regions of the world. Unfortunately, such regions are expanding and the magnitude of crisis is worsening. At the beginning of the 21st century, almost half a billion people face water shortages in 29 countries, one-third of the world's population is living under moderate to severe water stress, and 1.2 billion people lack access to adequate supply of safe water. Young children are more vulnerable than any other age group to the ill effects of unsafe water, insufficient quantities of water, poor sanitation and lack of hygiene. Globally, more than 125 million children under five years of age live in households without access to an improved drinking-water source, and more than 280 million children under five live in households without access to improved sanitation facilities. Globally, 10.5 million children under the age of five die every year, with most of these deaths occurring in developing countries. Lack of safe water, sanitation and adequate hygiene are the leading killers of children under five.

Estimates show that by 2025, almost two-thirds of the world's population (or close to 5.5 billion) will experience some type of water stress, and for over a billion of them, the shortage will be severe and socially disruptive. Nearly 2.5 billon people worldwide do not have access to proper sanitation. Seven million people die yearly from diseases linked to water, and half of the world's rivers and lakes are seriously polluted. Polluted waters are the cause of thousands of deaths every day, impact the health of the poor, check progress toward gender equality, and hamstring economic growth. According to World Health Organization (WHO, 2004), each day some 3,900 children die because of dirty water or poor hygiene. Water pollution is continuing to cause millions of preventable deaths every year. Global water biodiversity is declining significantly. Our ecosystems are either diminishing or vanishing rapidly. Pollution, deforestation, overfishing, and overexploitation of natural resources have led to the decline in populations of many species, ranging from fish to mammals, by one third over merely three decades from 1970 to 2003.

Consumption of Natural Resources and Current Life Style

According to the WWF Conservation Group, we are stripping nature at an unprecedented rate and if current trends continue we will need two planets' worth of natural resources every year by 2050. According to WWF, "If everyone around the world lived as those in America, we would need five planets to support us. On current projections, humanity will be using two planets' worth of natural resources by 2050, if these resources will not have already run out by then. People are turning resources into waste faster than nature can turn waste back into resources."

Clearly, humanity's footprint has more than tripled between 1961 and 2003. This rate of consumption of resources is not sustainable and lifestyles will have to change. The change would have to entail not only reducing the use of resources but also improved management of resources.

ENVIRONMENT

Environment means "surrounding conditions influencing development or growth". The surroundings encompass the whole complex of factors—the flora and the fauna; and the various life supporting systems, such as land, air and water. Environment can be considered a natural

resource. When this resource is over-exploited, problems arise.

Environmental 'hot spots' are the locations that have critical deficiency in assimilative or supportive capacity. Water, both quantitatively and qualitatively, is the limiting resource in most regions. Among natural resource development projects, water related projects have the most profound impact on the environment. The Environmental Impact Assessment (EIA) became an integral part of each important project in the 1990s. For many projects, social and environmental problems are now proving to be more difficult to handle than technical problems.

A major man-made intervention, such as a storage reservoir or extensive ground water pumping, changes the existing balance and forces the environment to seek a new stable state. The new state does not get established immediately; it takes time to get developed, and it might be better and acceptable or worse and distressing. Thus, it is necessary to ensure that any development does not aggravate the processes which are undesirable or harmful for the society. The magnitude of intervention is crucial. Any intervention that will adversely affect environment with consequential irreversible harm to life is to be checked. Further, no intervention is not always the right strategy.

Water and Environment

Water has a central and key role in the environment, but the contribution and importance of water in the environment are not the same in all geographical areas or all the year round in the same area. Depending on the location, topography, geology, and precipitation characteristics, some areas have higher water availability than others. The role of water in the environmental system also depends on other conditions. Many times, forests, pastures, agricultural cultivation, and urban areas provide different sets of environmental parameters. A change in the land use brings in a new 'environmental state' for water. The developmental potential also varies considerably from area to area. Many ills of the development programs for water have their roots in the inadequate appreciation of these differences and similar solutions for dissimilar environmental situations. Water management in arid regions must be different from that in humid areas. Vegetation is a good indicator of the availability of water in an area. Plants are an indicator of the quality of water in the ecosystem; all tree species do not survive well in saline or waterlogged areas.

Most environment-centered discussions and writings tend to be influenced by emotions and ignore the hard ground realities. However, the natural environment is not beautiful and pleasant everywhere. It can be extremely harsh, dangerous, ruthless and furious. Imagine the conditions in deserts, droughts, avalanches, cyclones, hurricanes, or rivers in spate. Even seemingly innocuous weather with temperatures close to 40°C causes several hundred deaths each year. Besides, the environment of a place, which is pleasant in one season, may become quite hostile in other seasons. Also, natural water is not always pristine and healthy as is widely believed. Pure rainwater, after falling on the earth and mixing with the pollutants, may no longer be fit for human consumption.

In many regions, because of poverty, lack of resources, and increasing pressure of the population, environment has been seriously degraded. Water management in such areas has, therefore, an additional important role—regenerating and restoring the lost plant life which, in turn, can support other life and lead to improvement in the environment.

Every effort to develop water resources results in some modification of the environment. Sometimes, the impact is confined mainly in the river course, aquifer or lake itself. In other instances, effects are much more widespread and may result in considerable alterations in land resources, forests or fisheries. Beyond this, Water Resources Development (WRD) may have major impacts on human settlements and economic activities. The extent of these impacts depends on the ability of various physical, natural and human systems to absorb them.

Earlier, environmental issues were not viewed with seriousness but the awareness has considerably increased during the past three decades. There is growing concern about the adverse social and environmental impacts of water development projects in many countries. The reason is the results of studies carried out all over the world which have demonstrated the significance of environmental impacts. Therefore, it has become imperative for any development plan, and especially WRD projects, to be evaluated from the environmental standpoint.

Climate Change

Climate change is a complicated subject. Data measurement networks are sparse and there is a great deal of uncertainty associated with our scientific understanding of the climatic processes. Nevertheless, there is a near unanimity that the climate is indeed changing in significant ways. As always, the first and the worst sufferers will be the marginal and the poor sections of the society.

Current change in climate is being triggered primarily by global warming. Accelerated burning of fossil fuels is the major cause of global warming. Years 2005 and 1998 were the two warmest years in the instrumental global surface air temperature record since 1850. Eleven of the 12 years (1995 to 2006)—the exception being 1996—rank among the 12 warmest years on record since 1850. Returning to the climate of 1970s (if at all) is possible only by cutting back industrial pollution, a conscious change in life style, and drastic reduction in the consumption of natural resources. But when we talk of these changes, the discussion takes on a political and social dimension. Mechanisms, such as Clean Development Mechanism (CDM), have been introduced. So far, more than 1000 projects have been registered under CDM (http://cdm. unfccc.int). Although CDM has spawned global trade of billions of dollars, the efficacy remains doubtful. Issues of and the road between climate science and public policy is not always straight and the ensuing ramifications can be far reaching, especially in developing countries.

In many parts of India, rural as well as urban, water tables have receded by tens of meters. Smaller rivers have disappeared. Thousands of rural ponds that used to harvest rainwater have vanished. Water shortage is noticed at many places. Cropping patterns have changed. Of course, many countries of the world are witnessing similar or even worse changes. These changes may be a harbinger of the future.

In the Himalayas, straddling India, Sikkim, Bhutan, Nepal, China, Afghanistan, and Pakistan, glaciers are melting due to rising temperatures and glacier lakes are growing both in number and size. Landscape is increasingly deteriorating, water supplies are dwindling, soil erosion is accelerating, biodiversity is vanishing, floods and droughts are becoming more imminent, rainfall patterns are changing and annual monsoon is becoming more unpredictable. These changes are having a calamitous effect on local populations and their entire way of life seems at risk. Whether all these changes can be squarely ascribed to climate change or global warming is difficult to say. Nevertheless its significant role cannot be denied. Increasing population, overgrazing, over-exploitation of resources, declining water tables, pollution, and unwise land use change also have a role to play.

WATER, ENVIRONMENT, ENERGY, AND SOCIETY

Burgeoning population is driving up demand for food and as a result changes in crop and livestock production are occurring, with profound environmental consequences. Increased application of nitrogen has led to increased crop production, but it also has had deleterious effect on the environment, such as decreased visibility from increased aerosol production, and increased nitrogen concentrations in surface and ground waters. Nitrogen compounds released into the atmosphere eventually find their way to the surface and impact human health and environment. Aneja *et al.* (2006) reported that domestic animals contribute approximately 40% of natural and anthropogenic emissions of ammonia. Synthetic fertilizers and agricultural crops contribute an additional 12% of total emissions. The influx of ammonia to the atmosphere has been more than doubled, greatly increasing the deposition of reactive nitrogen. Gaseous deposition from both crop and animal operations contributes to eutrophication and acidification of ecosystems. There is increasing public concern about potential human and environmental effects from air emissions caused by confined animal feeding operations.

Water and Energy

World energy consumption has greatly increased since the 1980s; currently it is expected to grow @ 2 percent/year. Water plays an important role in energy supply. Approximately 20% of world's electricity needs are met by hydropower. In Brazil and Norway, up to 90% of the electricity is supplied by hydropower. Besides, water is used for cooling in thermal electrical power stations, and also to generate nuclear power, tidal power, wave energy, and geothermal energy sources. Global industrial growths coupled with population increase are driving energy consumption to higher levels and this is the major reason behind steep rise of petroleum prices (around US # 130/barrel in May 2008). A fall out of this steep rise is that many countries are currently witnessing high inflation. Hydroelectric power is more or less insulated from inflation. Depending upon its phase of occurrence, water may generate energy (surface water) or energy may be required to use it (ground water).

Water and Sanitation

Environmental pollution is causing widespread public health problems, compounding water shortages and causing serious harm to ecosystems, especially in rivers, lakes, and coastal areas of the world. Adding to water pollution is increased human pressure on freshwater supplies. In industrialized countries, the quality of groundwater has significantly deteriorated

due to nitrogen leaching from intensive agriculture. The situation is even worse in developing countries.

Industries are one of the main water polluters in the world. Although pathogens are still a primary cause of disease in developing countries, chemical pollution by industries is a major cause of concern. Industries generate anywhere from 200 to 500 million tons of heavy metals, solvents, toxic sludge, and other waste accumulate each year (Shikhomanov, 1999). In developing countries, nearly 75% of all industrial waste and 90–95% of sewage are discharged into surface water without any treatment (UN/WWAP, 2003). Food and beverage industries that use organic raw materials contribute most to organic pollutant load. The food industry produces 40% of total organic water pollutants in developed countries and 54% in developing countries.

Access to adequate sanitation is a fundamental need and human right. Access to water supply also has considerable health and economic benefits to households and individuals. The lack of access to adequate water contributes to deaths and illness, especially in children. Thus, improvement in access to clean water is a crucial element in the reduction of under-five mortality, particularly in poor areas.

Although provision of safe drinking water and sanitation has been one of the guiding principles of many national and international programs, a significant volume of population, mostly poor people, is yet to receive assured water supply. Globally, more than 125 million children under five years of age live in households without access to an improved drinking-water source, and more than 280 million children under five live in households without access to improved sanitation facilities. No ready access to water also means that the considerable amount of time women and children spend for fetching water could be spent more effectively on other tasks, improving their economic productivity, a key component in poverty alleviation efforts.

Water borne diseases are the most important water quality problems affecting the society in India. Diseases occur when there is lack of sufficient quantity for washing and personal hygiene, which facilitates, among others, the spread of skin and eye infections (e.g., trachoma). Nearly half of the world's population suffers from diseases that are associated with insufficient or contaminated water.

Young children are most vulnerable to the ill effects of unsafe water, insufficient quantities of water, poor sanitation and lack of hygiene. Globally, about 20 lakh deaths occur each year due to diarrheal diseases—attributable to water, sanitation, and hygiene. Nearly 90% of those affected are children under 5 years of age; most of these deaths occur in developing countries.

About 2 million people die every year from diarrheal diseases (including cholera); 90% are children under 5 years of age, mostly in developing countries; 88% of diarrheal disease is attributed to unsafe water supply, inadequate sanitation and hygiene. Improved water supply reduces diarrhea morbidity by 21%. Worldwide, 1.2 million people die of malaria each year, 90% of whom are children under 5. Further, 6 million people are visually impaired by trachoma. This disease is strongly related to the lack of water combined with poor hygiene practices (lack of face washing), often due to the absence of nearby sources of safe water. Improving access to safe water sources and better hygiene practices can reduce trachoma morbidity by 27%.

Women and Water

Besides drinking, water is necessary for cooking food, sanitation, personal hygiene and health, cleaning, washing, waste disposal and for use by domestic animals—all these activities are largely the responsebility of women at the household level in almost all societies. Further, females have the greatest need for private and safe sanitation facilities. Women often have considerable knowledge regarding water sources, storage, conservation and management. But the potential contribution of women in water management and sanitation is often overlooked or not emphasized.

Women suffer disproportionately in water-generated disasters, such as floods, as they often do not get advance warnings or are unable to quickly get away. Unfortunately, women often have no voice in decisions about the kind of services they receive. Importantly, improvements in access to safe water and sanitation that involve women will lead to multiple benefits in other areas, such as reducing poverty, enabling girls to get an education, and reducing child and maternal mortality. Improving access to water allows women and girls to use the time spent collecting water on such other activities as attending schools, caring for children, generating income, and growing food for the family. If women are also involved in training programs for the operation and maintenance of water and sanitation facilities, it will help ensure sustainability of technologies and infrastructure.

Water, Environmental Management, and Religion

The significance and sanctity of water are emphasized in all major religions. In the Hindu religious practice

the Ganga, which comes directly from a holy source in the Himalayas, is considered to be the most sacred of all the rivers and is often referred to as mother Ganga. Immersion in the Ganga is said to bring believers purification and freedom from sins. Buddhists seek spiritual transformation (nirvana) in natural settings amid forests, rivers, and mountains and see the entire universe-humans, animals, water, earth, sun, moon, and stars-as an interdependent whole. In Islam, it was declared that ".... Heavens and earth were joined together—we made from water every living thing ..." (Holy Quaran, Soorat Al-Anbea, Verse 30). In Christianity, Baptizing or Christening by water is a symbol of the grace of God and signifies spiritual rebirth. Thus, water is not only the giver of life but is life itself for people and for the planet. Recall that when we talk of life on other planets, we first look for the presence of water.

In many parts of the world, religion plays a praiseworthy role in the care of water and environment. Leaders from the world's religious communities met at the United Nations in 2000 and signed the "Commitment to Global Peace," which included a call for the protection of the environment for present and future generations. As people face the challenge of sustaining the world's water resources today and for the future generations, religion can play an increasingly ethical and practical role. For example, the early Vedic traditions of Hinduism, described in scriptures and holy texts, extol the earth (bhu), the atmosphere (bhuvah), and sky (sva), as well as the Goddess associated with the earth (Prthivi), and the Gods associated with water (Ap), fire and heat (Agni), and wind (Vayu). The centrality of these gods and goddesses has been emphasized, suggesting an underlying ecological sensitivity within the Hindu tradition. In later Indian thought, these Vedic concepts became formalized into the Samkhya denoting the five great elements (mahabhuta): earth (prthivi), water (jal), fire (tejas), air (vayu), and space (akasa). The meditative and ritualistic practices of Hinduism entail awareness of these constituents of materiality. Daily worship (puja) employs and evokes these five elements. There is a lesson for all of us to learn from these religious precepts.

Rivers have been and continue to be an integral part of the Hindu religious practice. Traditionally, the rivers of India have been considered pure. More than fifty Vedic hymns praise the Sarasvati, a river (supposedly flowing underground—possibly denoting aquifers) associated with the goddess of learning and culture. Originating from the heavens, the pious Ganga River fell and got entangled in the hairs of Lord Shiva's head in the Himalayas. Shiva opened one lock to release a stream. Flowing through northern India, goddess Ganga gives sustenance to hundreds of millions of Indians. Modern industrial contaminants and human wastes have fouled the rivers, although Ganga water still plays an important role in India's spiritual and ritualistic life. One tenet of the Hindu spirituality is the doctrine of Dharma which emphasizes action "for the sake of the good of the world" which is in line with western thought. When considering the building of dams and other hydraulic works, this calls for taking into account social ecology or the need to integrate environmental policy with daily needs of the people.

Trees have also received a special place in religions of the world. For example, in Hinduism trees has long been revered. Early seals from the Indus Valley cities (ca. 3000 BCE) depict the tree as a powerful symbol of abundance. References to India's trees can be found in a wide range of literature, particularly in epic and poetic texts. There has been a long history of forest protection in India but rampant felling of trees by mafia in collaboration with corrupt government officers is not uncommon despite attempts such as the Chipko movement wherein women have staved off forest destruction by embracing the trees.

The current worldwide ecological crisis has emerged only during the past four decades and its effects have more recently been felt in South Asia. As this region copes with degrading air quality in its cities and degraded water in various regions, religious thinkers and activists have begun to reflect on how the broader values of Hindu tradition might contribute to fostering greater care for the earth. Gandhi's advocacy of simple living could be an answer to control rampant consumerism and associated problems. Most of the population of South Asia lives in villages that, barring natural disasters such as floods or droughts, are self-sustaining and use resources sparingly. However, as the population of South Asia increases, and as the modern lifestyle continues to demand more consumer goods, the balance of sustainability can shatter. With appreciation and acknowledgment of the five great elements, with a new interpretation of social duty (dharma) expanded to include the ecological community, and with remembrance of its ethic of abstemiousness, the Hindu tradition can develop new paradigms for caring for the earth and management of its resources.

Sustainable Environmental Management and Society

It is clear that sustainable water management is not possible without active involvement of all the sections

of the society. Habits of water and environment conservation need to be inculcated early in life by making it a part of the curricula in primary and secondary schools. Children, together with women, can form effective crusaders in sustainable hydro-environmental management.

In the past, desirable or good practices were propagated by labeling them as religious practices. With this view, natural elements and forces were recognized as Gods and the society was expected to protect and nurture them. Of course, the underlying objective was not to please these Gods but protect them and in turn protect ourselves. However, the influence of religion on people is waning and religion alone may not be able to impart the desirable influence on the needed change in life style and pattern of consumption.

Water and environmental management has now occupied the centre stage in the consciousness of the people in the light of perceived adverse consequences of climate change. Gradually, people are becoming more aware about the environmental damages arising due to their life styles and habits and are contemplating about changes in the habits so that global warming can be checked. If the people at large today realize that by damaging the environment, they are in fact causing harm to themselves in the long term, many of the problems associated with water and environmental conservation will vanish. To that end, a mixture of policy and paradigm changes involving religion, children, women and higher level of awareness appears to be a promising course of action.

SUMMATION

One of the most formidable challenges facing humankind in the 21st century is the supply of adequate quantities of water of right quality to meet domestic, industrial and agricultural needs in an environmentally acceptable way. This will require Integrated Water Resources Development and Management (IWRDM), a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Water is an economic as well as a social good that should be treated as a valuable and finite resource, and be equitably and sustainably allocated (Dublin Principles and Bonn Recommendations for Action). Water has also become a global commodity of strategic importance, because of increasing demands and rising costs, coupled with diminishing water supplies. Complex economical, social, environmental, technical, legal, institutional, ecological and physical issues notwithstanding, water resources projects must be planned, designed, constructed, managed, operated and maintained such that they can fully contribute to an improved quality of life for the present and future generations.

Religions of the world offer unique perspectives on the advocacy of what one might refer to as an earth ethic. For example, the variegated theologies of Hinduism suggest that the earth can be seen as a manifestation of the goddess (Devi) and that she must be treated with respect; that the five elements hold great power; that simple living might serve as a model for the development of sustainable economies; and that the concept of Dharma (duty) can be reinterpreted from an earth-friendly perspective.

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