Water in our future

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Introduction

The earth is a blue planet filled with water, but only a limited amount is the fresh water that is available to human life. Water use during 20th century has grown at more than twice the rate of the population increase, and already a number of regions are chronically suffering water stress. About one third of the world's population lives in countries that are experiencing moderate-to-high water stress partly resulting from increasing demands from a growing population and intensification of human activities. This tendency is never released and an estimate shows that by the year 2025, as much as two thirds of the world population could be under stress conditions. Future water issues are widely discussed and World Water Vision will become released in March, 2000 on the occasion of World Water Council scheduled at Hague. This short paper tries to show the fundamental problems related to water quantity and quality to be solved in order to establish a sustainable style of anthropogenic activities in the next century.

Water Quantity on the Earth

Global material cycles including water cycle are governed by the solar energy. The radiation energy from the sun reaches earth systems, 30% of which is directly reflected by air, clouds and earth surfaces into the space. The rest of the energy is absorbed by the atmosphere and the earth, which then emit the longwave (low temperature) radiation to the space.

Under these balances, grey gases in atmosphere and the earth surfaces exchange energy in the form of radiation, sensible heat and latent heat. The delicate balance thus established determines the environment where mankind can exist. The latent heat flux from the surface of the earth is transported in the form of water vapor from the ocean and the land areas, which eventually brings about precipitation of fresh water. Thanks to the unevenness of precipitation and evaporation on the ocean and on the land, fresh water becomes available in the form of running water from the land to the sea as shown in Figure 1.

Most of that freshwater is frozen in the ice caps of Antarctica and Greenland, and most of the remainder is present as soil moisture, or lies in deep underground aquifers as groundwater not accessible to human use. As a result, less than 1 per cent of the world's freshwater, or about 0.012 per cent of all the water on Earth, is readily accessible for direct human uses. This is the water found in lakes, rivers, reservoirs and those underground sources that are shallow enough to be tapped at an affordable cost. Only this amount is regularly renewed by rain and snowfall, and therefore available on a sustainable basis.

Much of the approximately 115×10^{12} tons of precipitation that fall on the continents each year evaporates back into the atmosphere, or is absorbed by plants. About 40×10^{12} tons of the water that falls on Earth flows through the world's rivers.[*1] When the world's total river flow is divided by the world population (of 1995), the quotient amounts to an average of 7,000 tons of water per person per year. Owing to the growing world population, this represents a drop of 37 per cent per person since 1970.

Freshwater resources are very unevenly distributed. The deserts are one extreme, where almost no rain falls, and the most humid regions are the other extreme, which can receive several metres of rainfall a year. [*2] The arid and semi-arid zones of the world, which constitute 40 per cent of the land area, have only 2 per cent of global run-off.

Even in parts of the world with large river flows, there can be a great amount of variability in terms of when and where

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the water is available. Most of the annual water flow may come as floods following snow melt or heavy rains and, unless captured by reservoirs, the water flows to the seas, sometimes causing seasonal flooding. Later in the year, the same areas may suffer droughts. Another major factor in the availability of water is the rate of evapotranspiration, the loss of water from land to the atmosphere by evaporation from the soil and water surfaces, and transpiration from plants.[*3] One more important factor is that much of the world's accessible run-off occurs in areas far from human settlements, and water is very expensive to transport over long distances.

It is estimated that the amount of freshwater that is readily accessible for human use is about $9x10^{12}$ tons per year and additional $3.5x10^{12}$ tons per year can be exploited by development and dams and reservoirs. In order to utilize the remaining water resource for human needs becomes increasingly costly, because of topography, distance and environmental impacts. Currently, humans are using about half the $12.5x10^{12}$ tons of water that is readily available. Given an expected population increase of about 50 per cent in the next 50 years, coupled with expected increases in demand as a result of economic growth and lifestyle changes, this does not leave much room for increased consumption. Figure 2 represents the amounts of freshwater in six continents. The size of population determines how much water is potentially available per capita.

Water Scarcity

Global withdrawals of water to satisfy demands have grown dramatically in 20th century. Between 1900 and 1995, water withdrawals increased by a factor of over six, more than double the rate of population growth. Figure 4 illustrates the global water withdrawal be sectors during this century. This rapid growth in water demand is due to the increasing reliance on irrigation to achieve food security, the growth of industrial uses, and the increasing use per capita for domestic purposes.

The increased demands are causing water stress in many areas of the world, even in some humid areas where rising demand or pollution have caused overutilization of the local resource. Already, about 460 million people, more than 8 per cent of the world's population, live in countries using so much of their water resources that they can be considered to be highly water- stressed. A further one quarter of the world's population lives in countries where the use of water is so high that they are likely to move into situations of serious water stress.

In some areas, the withdrawals are so high that the flow of rivers decreases as they move downstream, and some lakes are shrinking.

Groundwater supplies one third of the world's population, and is the main or only source of water for rural inhabitants in many parts of the world and also increasingly the main source for irrigation. Underground sources are being heavily overused in a number of regions, with water being pumped out faster than nature can replenish the supply. The excessive use of groundwater is likely to increase over the next 30 years. Overpumping groundwater has dropped water levels by tens of metres in places, making it increasingly difficult and expensive for people to have continued access to the water. In a number of regions, depletion has forced people to turn to lower-quality groundwater sources, some of which contain natural contaminants, such as fluorides and arsenics. The overuse of groundwater can have a serious effect on the base flow of rivers, especially during dry periods, which is so vital for aquatic ecosystems.

Water Quality

Major water pollution problems which are already well known include those described below:

(a) Health-related microbiological contamination: Contaminated water that people drink without adequate treatment is one of the major causes of human illness. Micro-organisms found in human and animal wastes include a wide range of bacteria, viruses, protozoa and other organisms that cause many diseases. These are present in virtually all wastes discharged, even those from most sewage treatment plants. It is essential to treat drinking water to

prevent illness.

(b) Surface water eutrophication: There is an accelerated growth of algae fertilized by the phosphorus and nitrogen present in many discharges, including human and animal wastes, detergents and run-off from agricultural fields. These two elements, when discharged into water, act as nutrients, greatly speeding up the process called eutrophication. Excessive algal growth leads to a decline in the oxygen content of the water, which can result in suffocation of some forms of aquatic life. It can also induce a maltaste and off-flavor in drinking water. Eutrophic ation is now leading to a decline in water quality on all continents. The draining of nutrients into oceans can lead to an increase in the number of toxic algal blooms, sometimes known as red tides, which can make seafood unsafe to eat.

(c) Groundwater pollution: Nitrates from fertilizers, human and stock wastes are polluting groundwater in many regions. High nitrate levels in drinking water decrease the oxygen-carrying capacity of haemoglobin in blood, which can threaten the health of infants. As a UN study has stated, nitrate pollution will likely be one of the most pressing water quality problems in Europe and North America in the coming decade, and will become a serious problem in other countries, such as India, China and Brazil, if present trends continue.

(d) Heavy metals in groundwater: Heavy metals are found naturally in soil and water, but their worldwide production and use by industry, agriculture and mining have released large amounts into the environment. The metals of greatest concern for human health are lead, mercury, arsenic and cadmium. Many other metals, including copper, silver, selenium, zinc and chromium, are also highly toxic to aquatic life. Water pollution related to metal production and use, including the release of acids from mining wastes, is a problem in many of the world's mining and metal processing regions. Elevated levels of some metals, such as lead and mercury, are also found around many cities, and downwind from metal smelters and coal-burning power plants.

(e) Man-made chemicals in water bodies: Some of the over 100,000 commercial chemicals in the world, as well as a number of by-product chemical wastes, are known or suspected to cause harmful effects in humans, plants and animals. The members of one class of compounds, known as persistent organic pollutants (POPs, which include such well-known substances as polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT), have created many of these problems because they are toxic, and highly persistent in the environment, and build up in the food chain. These and other chlorinated organic chemicals have been so widely distributed by air and ocean currents that they are found in the tissues of people and wildlife everywhere. Some of these chemicals are regarded to disrupt endocrine systems of animals including human, which then affects sustainability of natural ecosystems and eventually survival of humankind.

Theoretically, all pollutants can be removed from water but in practice, decontaminating water, especially in the case of toxic substances, is very expensive and requires sophisticated techniques.

Water pollution problems vary in severity around the world, depending on population densities, the types and amounts of industrial and agricultural development, and the number and efficiency of waste treatment systems that are used. The global magnitude of pollution is difficult to quantify because of a scarcity of information in many countries. There are estimates that in developing countries, which often lack the resources to build and maintain sewage treatment systems, 90 per cent of waste water is discharged without treatment.[*4] In most areas, domestic sewage volumes are far higher than those of industrial discharges.

Acidic precipitation is caused by sulphuric and nitric compounds released from such sources as industries, motor vehicles, power plants, smelters and incinerators.. This acid rain affects large areas of the world, including parts of Europe, North America, Latin America, India and Asia. It has killed parts of ecosystems, and can threaten human health by dissolving metals into the water. In addition to acids, there is long-range airborne transport of a wide range of chemicals and metals. Pesticide use is another important source because some of the chemicals evaporate into the air, and others adhere to tiny dust particles, and in both cases these chemicals can then be carried great distances by wind currents. Sometimes, the pollutants build up in the food chain, and are passed on to humans who rely on unprocessed foods.*5

Since most lakes and rivers eventually drain to the seas, the freshwater waste discharges also have an impact on coastal and even on deep-sea ecosystems. About 80 per cent of marine pollution is caused by human activities on land. The water in the oceans will never be clean unless pollution from land sources is controlled.

Human Health Issues

In the past two decades, these essential services were provided to millions of people worldwide, saving a great many lives and reducing illness. However, the rate of supply has not kept pace with that of population growth, and 20 per cent of the world's population lacks access to safe water supply, while 50 per cent lacks access to adequate sanitation.

WHO estimates that some 2 billion people are at risk of malaria alone, with 100 million people affected at any one time and between 1 million and 2 million deaths per year, a total of more than 5 million people die each year from diseases caused by unsafe drinking water, and a lack of sanitation and water for hygiene. Provision of safe drinking water and sanitation could reduce the amount of illness and death by as much as three quarters, depending on the disease. Not only is the toll a human tragedy, but it means these people are less able to carry on productive lives, and this undermines social and economic development.*6

In humans, high levels of exposure to some chemicals and heavy metals have been linked to a number of illnesses, including cancer, damage to the nervous system and birth defects. Pollutants can build up in the food chain to the point where they harm people, as in Minamata disease which is caused by the eating of seafood contaminated with mercury from industrial discharges. The cumulative effects of long-term exposure to a variety of chemic als at what seem like low concentrations cannot be well quantified at present.*7

Toxic chemical effects have been more clearly recorded in wildlife. The effects include cancer, death, eggshell thinning, population declines, reduced hatching success, abnormal behaviour, changes in organ development, infertility, birth defects and a range of other illnesses.*8

Water Stress

It has been observed that water stress can begin once the use of freshwater rises above 10 per cent of renewable freshwater resources, it becomes more pronounced as the use level crosses the 20 per cent level, and it gives a heavy burden if the level becomes more than 40%.

On average, a country can only capture about one third of the annual flow of water in its rivers using dams, res ervoirs and intake pipes. A further limitation arises from the growing lack of acceptance for the social and environmental impacts of large dams. The closest and most economical sources of water are used first, and it becomes increasingly expensive to tap sources that are farther away from the site of needs. Another limitation on water use stems from the fact that once withdrawals pass certain thresholds, which vary from site to site, lake and river levels fall to the point where other uses are harmed.

Figure 2 presents water withdrawal as a percentage of water availability in 1995.[*9] Here, four categories of water stress are adopted on the amount of available freshwater. Figure 3 is prepared in a similar manner on the basis of expected population increase and economical development in each country.

Concluding Remarks

Water stress should be released by combining water resources and demand balance based on local conditions such as climate conditions, industrial and agricultural activities and their water needs, economic conditions, traditions and culture. Problems are summarized as below:

Developing countries

Abundant water resources are found in some of the developing countries, for examples countries in tropical humiid area. They often suffer from floods that occur during a short period of monsoon and rainy season, which causes damages to villages and farms. Because of the poverty of these countries, they do not have sufficient drinking water supply and sanitation system.

Developing countries in arid and semi-arid zones have limited water resources but are characterized by little water stress. This is because people are too poor to utilize water resources. They lack a system for development such as financial resources, technical expertise and institutional support. They needs adequate water supply, sanitation and wastewater treatment. In cases when there is high economic and population growth, the country may face a severe situation in terms of a water demand and supply balance. They need to consider restructuring production and consumption patterns away from wasteful and low-value, water intensive uses.

If countries are well endowed with land and water resources, they may have the opportunity to increase agricultural production and exports into the world market. Some of the poor countries lack adequate access to possibilities that their water has. Development assistance could help them in using that water wisely.
Most of the new population will be found in the developing world, and these countries will move from being 37 per cent urban in 1995 to 56 per cent urban in 2025. At the same time, there will be more industrial development. These trends will take both people and water supplies from agriculture, creating an urgent need for more urban sanitation. Peri-urban agriculture is also increasing

These countries may need to adopt the following strategies:

(a) High water stress countries should shift to more high-value, less water-intensive crops, and develop the associated agricultural industries to process more of the products, thus raising the value-added component in their countries.
(b) Countries are urged to give high priority to investments for wastewater treatment and reuse, and to formulate and implement pollution monitoring and control policies.
(c) They should develop the educational and information infrastructure necessary to improve skills of the labor force required for the industrial transformation that needs to take place.
(d) For aiming short-term economic growth, highly polluting industries with little or no control on their discharges may be accepted. However, it should be noted that the overall long-term costs to redress environmental damages resulting from such decisions have often been shown to be more expensive than the creating of low-polluting industries in the first place.

Developed countries

For developed countries, the main problem is water pollution rather than supply, although some large countries contain water-poor regions. They have the financial resources to deal with regional water supply problems, often by means of water diversions. Pollution reduction and control are the major challenge for most countries in this category. Some of the developed countries have fairly large amounts of water, but are facing stress conditions as a result of continuing overuse and pollution of their water resources which will be causing problems, such as groundwater depletion, in the near future.

Other countries, however, have already used most of their accessible water resources. They have little scope for increasing the amount of water supplied to human uses through conventional means without inflicting damage on aquatic ecosystems, or seriously depleting groundwater aquifers.
Demand management and water allocation policies designed to maximize the socio-economic value of water are most significant, as is pollution control.

Water-pricing should be considered seriously since future abusement of water must be avoided. Some countries in this category with favorable land and climate conditions, may have a significant potential for increased food production and could play an important role in providing food to world market.[*15]

Wastewater treatment and reuse, together with holistic restructuring of industrial/domestic activities themselves will constitute essential mechanisms for pollution control and the minimizing water abuse.

Development of water-related technologies such as a technology to upgrade deteriorated water quality in developing countries is one of the most urgent policies to undertake in developed countries. Especially technologies to fit with the economic conditions of developing countries are mostly needed.

As water becomes more scarce in relation to demand, and competition among various users increases, water ceases to be available as a free good and becomes in many areas a tradable commodity. There is a shift taking place in the role

of Governments - a shift from their role of providing water at very low cost, to one of regulating water markets.[*11]

References

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