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An Overview of the Global Water Problems and Solutions

1. General Situation

Water is essential for human life, development and environment, but it is a finite and vulnerable resource which has quantitative limitations and qualitative vulnerability. As People Action International (PAI, 1997) states, water is the source of life and development on earth. Life is tied to water, air and food, while food is tied to water. Water is a regional resource, but water shortage is becoming a global issue due to increasing population, economic growth and climate change. Development of new sources of water beside its efficient use, together with conservation measures, should be an important component of any country's national water plan.

According to a PAI (1999) estimate, there were 31 countries with a total population of 458 million which faced water stress in 1995. More seriously over 2.8 billion people in 48 countries will face water stress by 2025, based on United Nations medium population projections, see Figures 1 and 2 and Appendix A1. Figure 1 shows the number people in water scarce countries and Figure 2 indicates the world's freshwater supplies in 1995 and 2025. Of these 48 countries, 40 are in the Middle East and North Africa. Hinrichsen (1999) predicts that population increase alone will push all of the Middle East into water scarcity over the next two decades.

Gleick (2000) indicates that there are five major drivers demanding a huge expansion of water resources in the 20th century: population growth, industrial development, expansion of irrigated agriculture, massive urbanisation and rising standards of living. Figure 3 depicts the world population, water use and irrigated area since 1900 to 2000. As seen in this figure, the world population has grown from 1600 million to more than 6000 million over the last century. Land under irrigation increased from around 50 million hectares to over 267 million hectares. All these factors have led to more than six-fold increase in freshwater withdrawals, from 580×10^9 m³/y estimated for 1900 to 3700×10^9 m³/y in 2000.

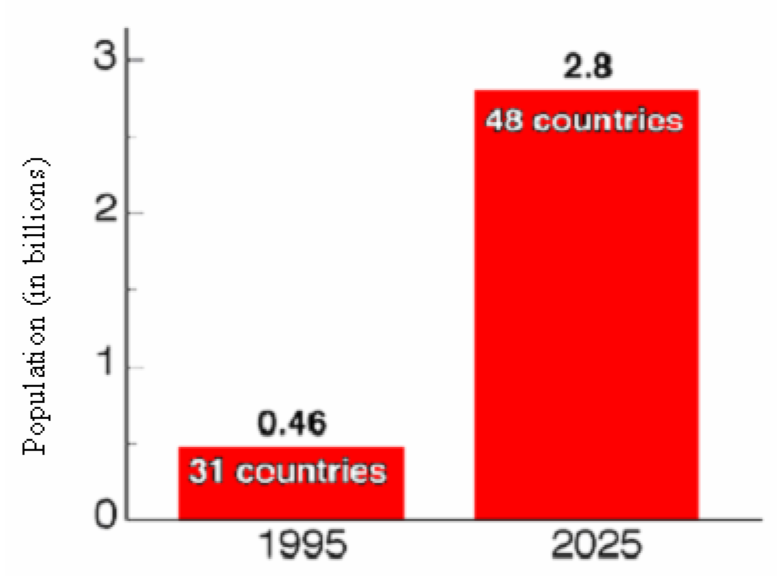

Figure 1. Population in water scarce and water stressed countries, 1995 – 2025, (Hinrichsen, 1999).

From the above discussion and a comprehensive analysis of the literature, it may be concluded that the world is already facing severe water-related problems. These may be identified as follows:

- 20% of the world's population or more than 1 billion people lack access to safe drinking water, (Simonovic, 2000), see Figures 4 and 5. Figure 4 shows the population without access to safe drinking water and Figure 5 shows the distribution of unserved population in water supply and sanitation.
- 50% of the world's population or more than 3 billion people lack access to sanitation, (Cosgrove, 2000), as shown in Figure 5.
- About 80% of all illnesses and more than one third of all deaths in developing countries are related to water. It is estimated that worldwide, around 7 million die yearly from diseases linked to water. Every eight seconds a child dies from a water-related illness, that is about 4 million a year, (UNEP, 1999 and Serageldin, 1999).

- Half of the world's rivers and lakes are seriously polluted. Pollution of the waterways and surrounding river basins have created millions of environmental refugees, (Serageldin, 1999).
- Major rivers - from the Yellow river in China to the Colorado in North America are drying up and barely reaching the sea, (Serageldin, 1999),
- Nearly half a billion people in 31 countries face water shortage problems, a figure that is anticipated to rise to nearly two-thirds of the world population by 2025. The worst areas comprise the entire Mediterranean region, including parts of southern Europe, North Africa and Middle East, Northwest and south India, Mongolia, northern China, most of Sub-Sahara Africa and major regions in North and South America, especially the western United States. They will face severe water shortages in the coming years. Europe as a whole also faces severe problems, because half of its lakes have already atrophied, (Cosgrove, 2000 and Serageldin, 1999).
- Aquifers are being extracted at an extraordinary rate - 10% of the world's agricultural food production depends on using extracted groundwater. As a result, groundwater tables fall by up to several metres a year - with the risk of collapse of agricultural systems based on groundwater irrigation in the north China plain, the USA high plains and some major regions depending on aquifers in India, Mexico, Yemen and elsewhere, (Serageldin, 2000).
- Some of the world's biggest cities, including Beijing, Buenos Aires, Dhaka, Lima and Mexico City, depend heavily on groundwater for their water supply. The current overuse is not sustainable, because it takes many years to fill aquifers. Groundwater from aquifers under or close to Mexico City, for example, provides it with more than 3.2 million m^3 per day, but already water shortage occurs in many parts of the capital. A related effect is that Mexico City has sunk more than 10 m over the past 70 years. Bangkok, similarly depleting its aquifer for drinking and sanitation, is also slowly sinking. Most of the world's megacities are located on coast lines, where aquifer depletion leads to saltwater intrusion and the contamination of freshwater, (UNEP, 2000 and Cosgrove, 2000).

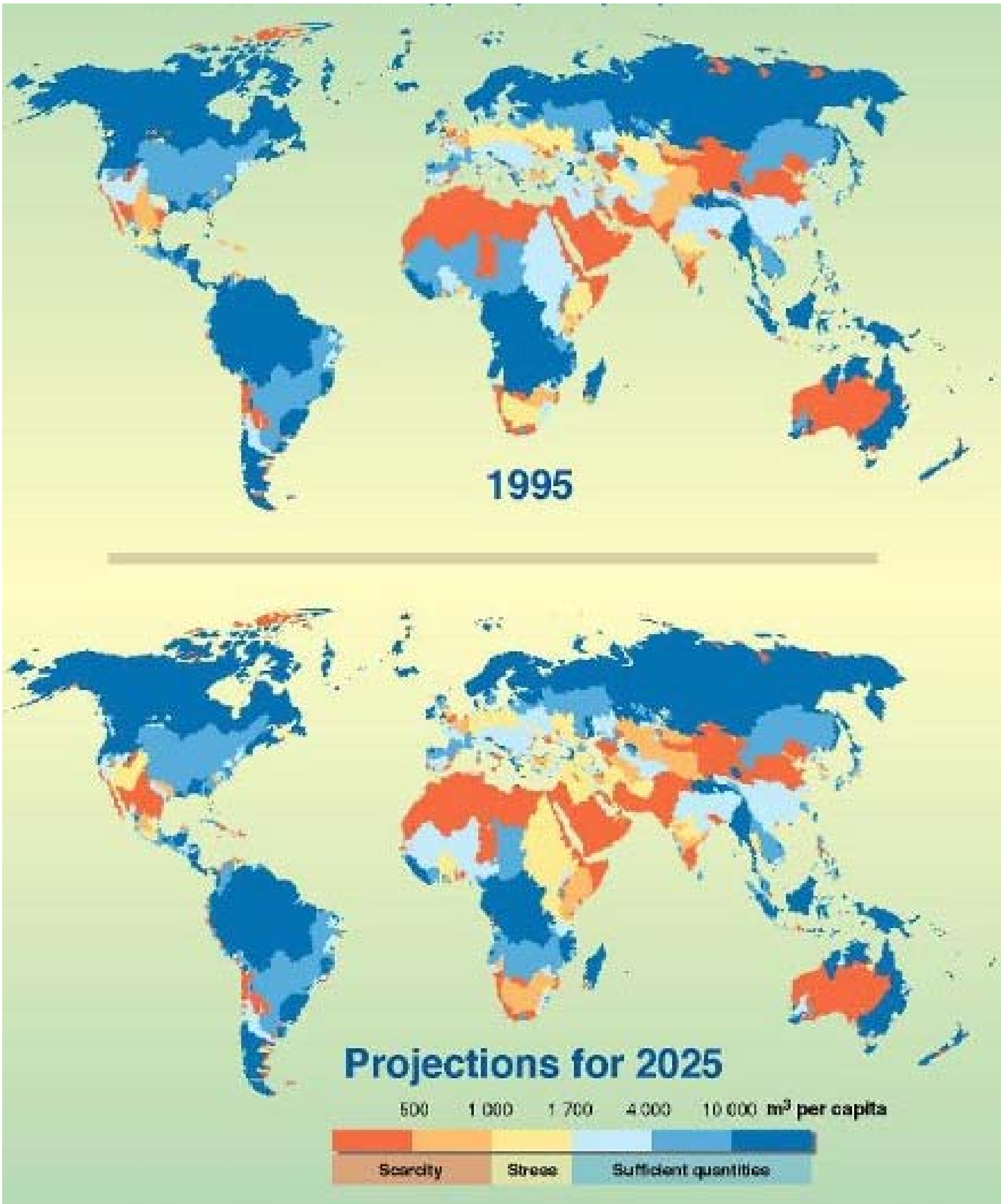

Figure 2. The world's freshwater supplies – annual renewable supplies per capita in 1995 and the projection for 2025, (UNEP, 2002).

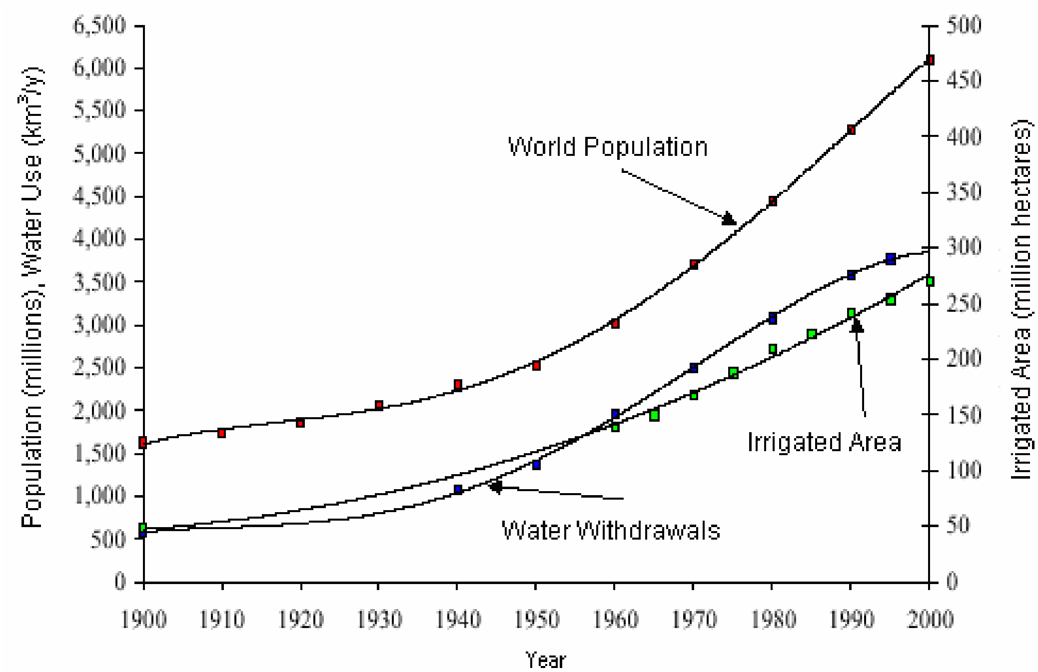

Figure 3. World population, water use and irrigated area, (Gleick, 2000).

- Diverting water for irrigation in Central Asia has caused devastating effects. A notorious case is the Aral Sea. This has shrunk to a fraction of its original size and badly degraded in water quality. The latter has caused hundreds of thousands of people to suffer from anaemia and other diseases due to the consumption of water saturated with salts and other chemicals coming from the cotton fields, (Serageldin, 2000).
- Transmission of water itself causes severe problems. The supply system of large European cities, for example, can lose up to 80% of the water transported because of pipe damage; with some Mexican cities losing up to 60% through leakage from their old supply systems, (Dossier, 1997). Countries like Bangladesh, the Philippines and Thailand experience water losses of 50%. In Middle East countries like Jordan, Yemen and others with rising water scarcity, more than 40% of the available water cannot be traced, (Chaturvedi, 2000).

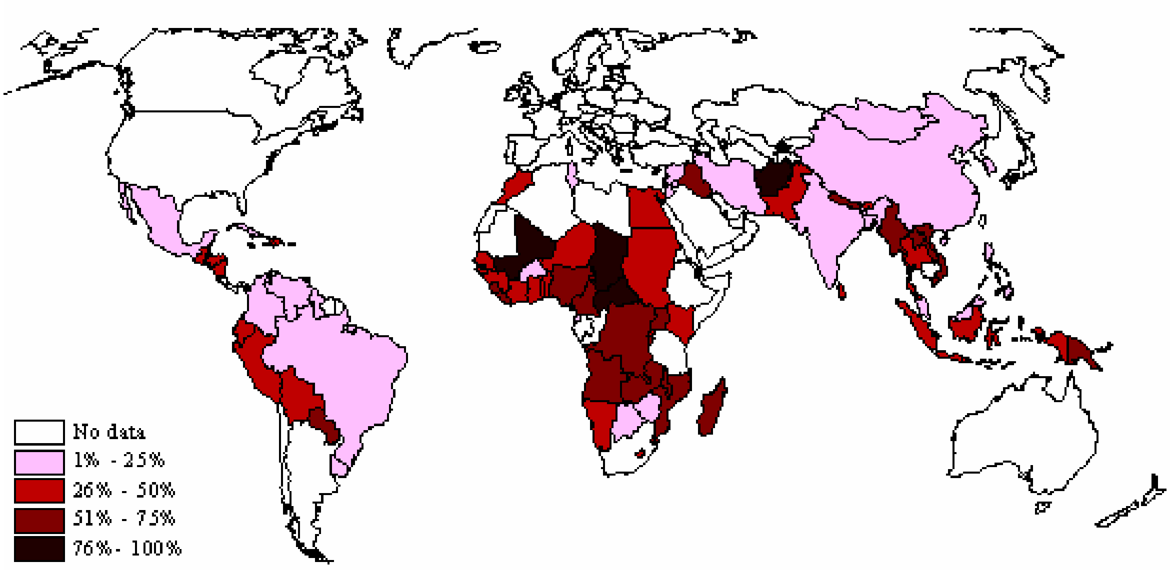

Figure 4. Population without access to safe drinking water, (Gleick, 1998).

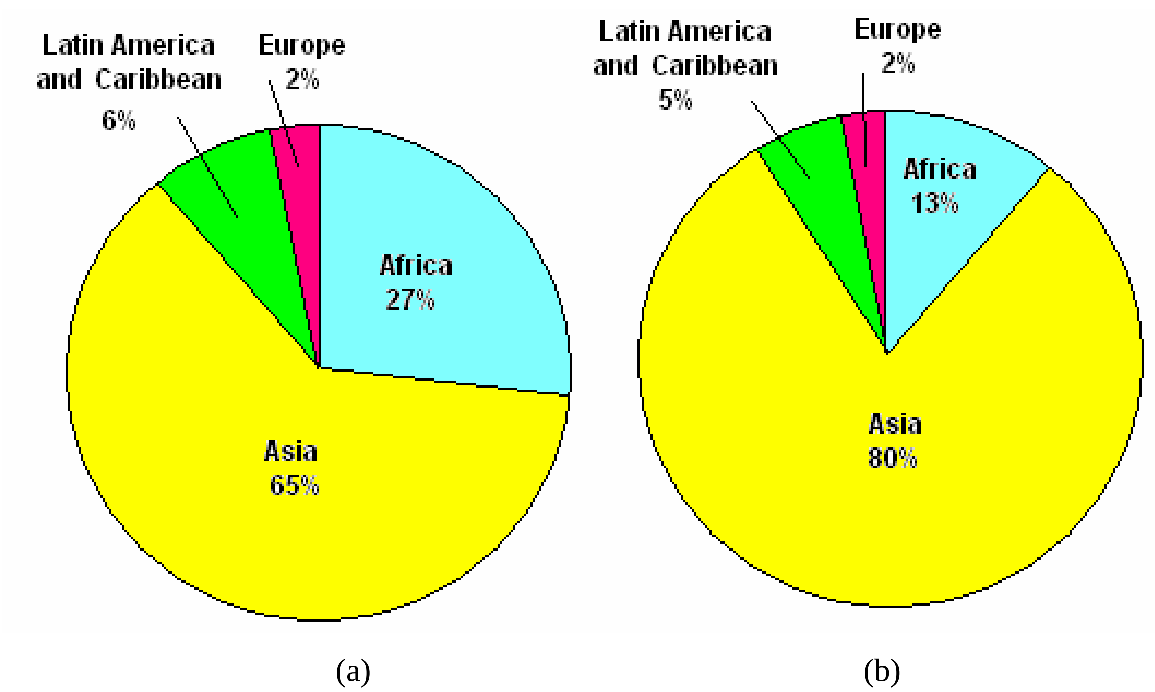

Figure 5. Distribution of unserved populations in (a) Water supply and (b) sanitation, (UNESCO, 2003).

2. Water Problem Assessment

Water problem assessment comprises reliable assessment of water availability, water quality, water needs and water shortage. Each of these aspects is discussed below.

2.1. Water Availability

Water is the most widespread substance on earth. It covers more than 70% of the world's surface. It forms oceans, seas, lakes, rivers and the underground water. In a solid state, it exists as ice and snow cover in polar and alpine regions. A certain amount of water is contained in the air as water vapour, water droplets and ice crystals, as well as in the biosphere. Huge amounts of water are present in the composition of the different minerals in the earth's crust.

The above description may be re-expressed quantitatively. According to UNEP (2002) the total amount of water on the Earth is about 1400 million km^3. About 97.5% of this amount is saltwater and only 2.5% or about 35 million km^3 is freshwater. The greater portion of freshwater (around 69%) is in the form of ice and permanent snow cover in the Antarctic, the Arctic and in the mountainous regions. Around 30% exists as fresh groundwater. Only about 0.3% of the total amount of fresh water on the earth is concentrated in lakes, rivers, soil moisture and relatively shallow groundwater basins where it is most easily accessible for economic needs and extremely vital for water ecosystems.

Availability of freshwater depends on the evaporation from the surface of the oceans, i.e. the earth's water cycle. This cycle works like a huge water pump which transfers freshwater from the oceans to the land and back again. In this cycle, water evaporates from the earth's surface, into the atmosphere and is returned as rain or snow after condensation. Part of this precipitation evaporates back into the atmosphere, some flows into streams, rivers and lakes, and returns to the sea, and the rest is absorbed by the ground and becomes soil moisture or groundwater.

To assess water resources in a region, two concepts based on water exchange characteristics are often used in hydrology and water management: a resource is defined as having static storage and renewable components. Static storage includes freshwater with a period of complete renewal taking place over several years or decades such as large lakes, groundwater, or glaciers. Intensive use of this resource inevitably results in depleting the storage components and has adverse consequences. It also disturbs the natural equilibrium established over centuries. Its restoration may require tens or hundreds of years. The renewable component replenishes annually which includes runoff from rivers within a specific region or from external sources, including groundwater inflow to a river network. In practice, the value of river runoff is used to estimate water availability and/or deficit in water resources for any region.

According to UNSD (1997) a key characteristic of the world's freshwater resource is its uneven distribution and variability with respect to time and space, which is dictated largely by climate: conditions ranging from arid deserts, with almost no rainfall, to the most humid regions, which can receive several metres of rainfall a year, as shown in Figure 6. This figure depicts the aridity zones of the world. Helweg (2000) states that a feature of semi-arid areas is that precipitation comes all at once and is highly variable; it means that water may be available but not at the right time or place. Based on OECD (1999) projections, arid regions already occupy 30% of Europe, 60% of Asia, the greater part of Africa and the south-west regions of North America, 30% of South America, and most of Australia.

Ponniah (1998) describes that the value of water resources has a number of important dimensions. These are based on the three factors of timing, location and reliability. Water resource issues are local or regional in nature: adequate supplies in one region cannot assist water-deficit regions unless there are facilities to transport supplies between regions. Even in regions with large river flows, there can be a great amount of variability in the water availability.

Extreme events of water such as floods and droughts form another important characteristic of water. Most of the annual water flow may come as floods following snowmelt or heavy rains, and unless captured by reservoirs, it flows to the seas, sometimes causing seasonal flooding. Such areas may suffer droughts later in the year. These characteristics show the first particularity of water: its quantitative limitation.

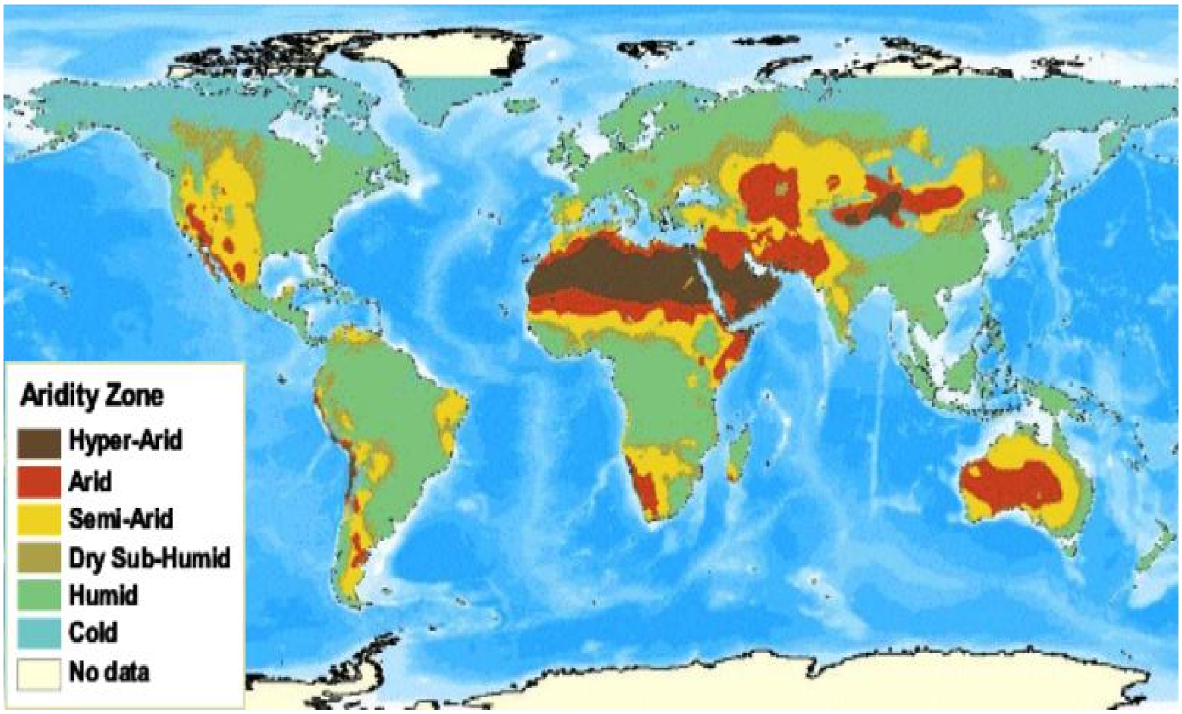

Figure 6. Aridity zones of the world, (WRI, 2002).

Water can be misused, polluted or its flow pattern and chemical properties can easily be changed by human activities and other factors. Hence water vulnerability is another key characteristic of the world's freshwater resource. Most aquifers receive little or no recharge and can be depleted through pumping. Pumping from aquifers near a coastline reduces the natural discharge of freshwater and causes saltwater intrusion. Hence water quality is another important aspect of water supply. Water is rarely pure and it can be polluted by different sources of pollution. These characteristics demonstrate the second particularity of water: its qualitative vulnerability.

Shiklomanov (2000) states that due to rapid global population growth between 1970 and 1994, the potential water availability for the earth's population decreased from 12900 to 7600 m^3 per year per person. The greatest reduction in annual per capita water supply took place in Africa (by 2.8 times), Asia (by 2.0 times), and South America (by 1.7 times). Water supply in Europe decreased for the same period only by 16%. According to Ladner (1998) global average of per capita freshwater availability is reducing by 5% every year due to population increase and pollution.

According to Niemczynowicz (2000) the amount of renewable water is around $42{,}000 \times 10^9$ m^3/y which replenishes aquifers or returns to the oceans by rivers. Most of it (around $30{,}000 \times 10^9$ m^3) is in flush flows that are not captured by man. It is assumed that between 9000×10^9 and 14000×10^9 m^3 per year form available renewable freshwater resources. But about 70% of that is needed to sustain natural ecosystems and only 30% or 4200×10^9 m^3/y remains for all human uses. This volume divided by 6 billion people gives 700 m^3/person per year. Irrigation is the largest water consumer using about 69% of freshwater (483 m^3/person per year), followed by industry using 23%, (161 m^3/person per year). Thus only 8% or 56 m^3/person per year or 153 litres per person per day (l/pd) remains on average for all domestic uses in the world, as shown in Figure 7. This figure shows the global availability and uses of freshwater.

Ladner (1998) proposed that at least half of the available freshwater has to be left for the overall life supporting ecosystem comprising of plants, forests, animals, birds and insects in addition to environmental subsystems like wetlands, lakes, backwaters and low lands. Hence, an annual global withdrawal of freshwater of the order of 5000 km^3 or more is likely to endanger the planet's ecology and environment. According to him, this 5000 km^3 is a critical figure. This corresponds to 183 l/pd as a theoretical global water availability figure.

Niemczynowicz (2000) also identifies an interesting coincidence in that European average water consumption of around 200 l/pd slightly exceeds the above calculated global water availability. Some developed countries (e.g. USA) use much more, about

600 l/pd, and many developing countries use much less. An absolute minimum might be around 5 or 6 l/pd which is approximately that used by a nomad in Sahara.

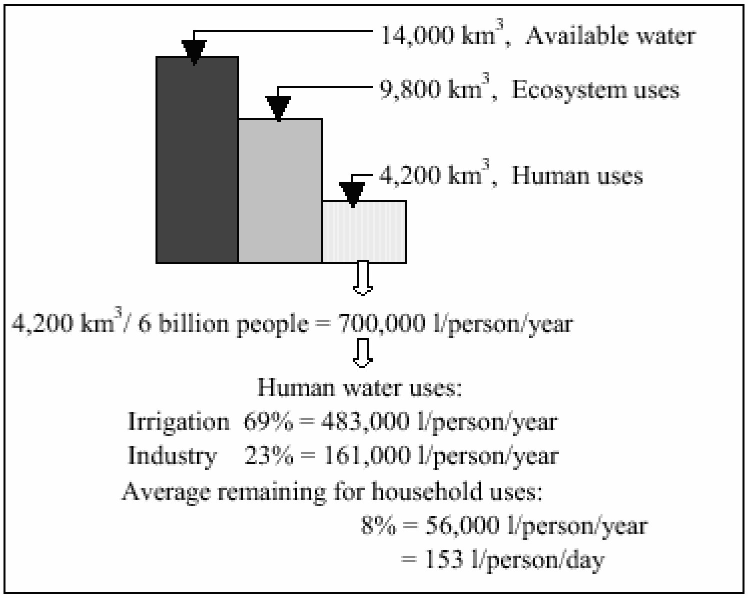

Figure 7. Global availability and uses of freshwater, (Niemczynowicz, 2000).

In addition to the above, however, according to WRI (1999) water availability on the basis of global per capita figures provides a false picture. For example, in some cases water is not where it is wanted and in other cases, there is too much water in the wrong place at the wrong time. About three-quarters of the annual rainfall occurs in areas containing less than one-third of the World's population. It means that two-thirds of the World's population live in areas receiving only one-quarter of the world's annual rainfall. For instance, about 20% of the global annual rain runoff each year occurs in the Amazon basin. This is a vast region inhabited by somewhat more than 10 million people, only a tiny fraction of the World's population. Similarly, the Congo River and its branches receive about 30% of the entire African continent's annual runoff, but the watershed contains only 10% of Africa's population. According to PAI (1999) in 1995 the estimated amount of renewable freshwater available per capita on an annual basis ranges from over 600,000 m^3 in Iceland to less than 100 m^3 per person in Kuwait, Malta and Qatar.

Fredrick (1999) states that water-short societies and many countries attempted both to move water from where it occurs in nature to where people wanted it and also to store water for future use. Human efforts to change the water cycle date back to ancient times. Primitive societies tried to bring rain through prayer, rain dances, human and animal sacrifices and other rituals. According to Helweg (2000) Persians constructed hundreds of Karize’s, tunnels used to bring water from an underground source in the mountainous area down to the foothills. This method of irrigation spread over the Middle East into North Africa over the centuries and is still used today. The ancient Egyptian economy was centred round the annual flood pattern of the Nile. Mays (1996) describes how the Egyptians built thousands of canals and irrigation ditches to capture the Nile's waters in order to grow crops. Over last few centuries BC, Roman engineers brought water to Rome via several aqueducts from as far away as 100 km.

One of the key water control structures is that of the dam. According to McCartney (1999) and Cosgrove (2000) there are around 40,000 large dams (higher than 15 metres) and more than 800,000 smaller ones worldwide. Most of them were built in the last 50 years with a combined capacity of 6000 km^3. They offer development benefits through hydropower, drinking water supplies, flood control and recreation opportunities. Although dams help ensure a steady water supply, they often endanger aquatic ecosystems (plant and animal life) by disrupting flood cycles, blocking river channels, altering water flows in rivers, floodplains, deltas and other natural wetlands.

2.2. Water Quality

Conner (1998) states that during the water cycle, water quality may take many aspects. Over this repetitive cycle, a single water molecule may assume various states, returning to the basic hydrologic pathway as new chemical compounds are mixed with various solid and liquid substances. Hence, water is often qualified as: pure, natural, salt, fresh, polluted, drinking, spring, mineral, bottled, tap, filtered, rain, raw, spa, distilled, etc. What do all these names mean?

Pure water contains water molecules only (H_2O - two parts hydrogen and one part oxygen), with no suspended or dissolved material. Away from that, its composition depends on where it comes from, and how it is processed and handled. Pure water does not exist in nature due to its solvent action; it dissolves at least a portion of everything it contacts.

Natural water contains different minerals and gases. The quantities of these depend on the source of water and especially on the terrain through which it flows. Therefore the quality of water varies substantially from area to area. In some cases, the quality of water in a given area can alter even on a day to day basis.

Saltwater, which covers about 70% of the earth surface (oceans and seas) is so called as it contains a certain amount of dissolved salts (about 35000 ppm), (Conner, 1998). Saltwater is not suitable for drinking, because it dehydrates, that is salt drains water from human bodies. In order to drink saltwater, it needs to undergo desalination.

Freshwater is water with a dissolved salt concentration of less than 1%. There are two types of freshwater reservoirs: surface water (water collected as rain and snow runoff and groundwater seepage, collected in reservoirs, lakes and rivers) and groundwater (water contained in underground aquifers that reach the surface through springs, deep wells or artesian wells).

Polluted water: freshwater is drinkable if it is not polluted. Polluted water contains harmful bacteriological and/or chemical substances such as bacteria, toxics, nitrates, heavy metals, hydrocarbons, pesticides, etc.

The bacteriological contamination of water is the main problem in developing nations. It is necessary to make appropriate tests to determine if water is bacteriologically safe for human consumption. Also, control procedures are needed, involving chlorination and filtration or boiling.

Toxic chemicals are of serious concern in developed countries: they enter water from many sources including industry, agriculture and the home. Little is known about the effects of these toxic substances on human health. Their effects often do not become noticeable for long periods of time and it is difficult to distinguish them from the effects of other factors that impact on day-to-day life, such as nutrition, stress and air quality.

Water pollution is a new problem approaching crisis levels in many parts of the world. Polluted water is a major cause of death and disease in the developing world. According to Love (1999) an estimated 80% of all diseases and over third of deaths in developing countries are caused by the consumption of contaminated water. Water-related diseases cause a 10% reduction in overall production effect. Gleick (2004) has classified water-related diseases into four categories:

The first group is waterborne diseases caused by water which has been contaminated by human, animal or chemical wastes such as cholera, typhoid, amoebic and bacillary dysentery and diarrhoeal diseases.

The second class is water-washed diseases caused by poor personal hygiene and skin or eye contact with contaminated water such as scabies, trachoma and flea-, lice- and tick-born diseases.

The third group is water-based diseases caused by parasites found in intermediate organisms living in water such as dracunculiasis, schistosomiasis and other helminths.

The fourth group is water-related insect vector diseases caused by insects that bread in water such as dengue, filariasis, malaria, onchocerciasis, trypanosomiasis and yellow fever.

Drinking water comes from municipal water systems, wells or springs. It is often treated to remove bacteria and other pathogens and pesticides. In general, water for drinking and cooking should be healthy – free of harmful bacteriological and chemical components. In addition, drinking water should be clear, colourless and have no unpleasant taste or odour.

According to IAEA (2000) there are several drinking water standards defined by the World Health Organisation, the European Union and other countries and organisations. The United States Environmental Protection Agency provides a double set of standards for water in terms of its suitability for drinking (in the Primary Drinking Water Regulations) and for aesthetic considerations (in the Secondary Drinking Water Regulations).

Spring water is groundwater that has arisen naturally to the surface. It may contain a range of minerals and is, hence, quite flavourful. Artesian spring water or artesian well water also rises under its own pressure, but only after it has been reached by drilling.

Mineral water is bottled water that contains minerals, that is naturally or artificially impregnated with mineral salts or gases such as CO_2. Weil (2005) estimates that on average, over 95% of the major and trace minerals ingested daily (by weight) come from food (fruits, vegetables, animal products) and less than 5% from drinking water.

Bottled and Tap water – public water systems and bottled water generally are disinfected, the former with chlorine and the latter by ozone treatment. Ozone is a strong oxidant, but it does not add taste. Chlorine usually provides residual disinfection throughout a public-water distribution system, but ozone provides a residual disinfection for a limited time. In terms of bacterial content, it is doubtful whether bottled water is better than most municipal tap water.

Many people purchase bottled water because of concern over the quality of their tap water or for its good taste. Nevertheless, taste does not always indicate safeness. Differences in taste among bottled waters generally are due to different amounts of minerals and types of processing. From the point of view of contamination, bottled water is no better than that from municipal supplies.

According to Gleick (2004) sales and consumption of bottled water have hugely increased in recent years. From 1988 to 2002, the global sales of bottled water have more than quadrupled to over 131 million m^3 annually. Bottled water typically costs 1000 times more per litre than high-quality municipal tap water. Most homes in the UK are supplied with mains water from a public water supply and although only about 2% of domestic water supplied is used for drinking and cooking, it all has to be categorised as "fit for drinking", see Appendix A2.

Filtered water – filtering describes the physical removal of particles through the use of a fine membrane. Conner (1998) states that while filtering can remove chlorine, some suspended substances and many synthetic chemicals from water, it is not possible to filter out bacteria or viruses, due to their size of about 0.001 microns.

Rainwater is water falling in drops condensed from vapour in the atmosphere. This should in principle form an ideal pure water, but today atmospheric air is so polluted that it poisons and contaminates this natural otherwise pure water.

Raw water is water which has not been treated in any way.

Spa water is water from a mineral spring.

Distilled water is pure water containing no contaminants. It is rather flat and tasteless when drunk because of its lack of minerals. This is because the sensation of taste with water is not due to the water itself, but to the permitted additives, such as chlorine (in tap water), iron (in well water) or minerals (in bottled or spring water).

2.3. Water Needs

It is difficult to estimate the amount of water essential to maintain a minimum living standard partly because this itself requires careful definition. Furthermore, different authorities use different figures for water consumption, both in total and for each sector of the economy. This important aspect is now reviewed in some detail.

A person needs 1 or 2 litres of water a day to live, but water is also required for domestic needs, industry and agriculture. Several different amounts have been proposed as minimum standards. UNDP (1994) estimates that human beings need about 5 litres of water each day for cooking and drinking. In addition, good health and cleanliness require a total daily supply of about 30 litres per person. Gleick (1999) proposes that international organisations and water providers adopt "an overall basic water requirement of 50 l/pd" as a minimum standard to meet the four basic needs of drinking (5 l/pd), cooking (10 l/pd), bathing (15 l/pd) and sanitation (20 l/pd). Falkenmark (Gardner, 1997) doubles this figure to 100 l/pd for personal use to give a minimally acceptable standard of living in developing countries. This figure excludes usage for agriculture and industry.

The amount of water used in a country, however, does not depend only on minimum needs and/or how much water is available. It also depends on the levels of economic development and urbanisation. In fact, the amounts for personal use (drinking, cooking and sanitation) are small compared with other uses. As mentioned earlier, on a worldwide basis, agriculture accounts for about 70% of all annual water withdrawals; industry about 20% and domestic use about 10%, (Cosgrove, 2000 and Serageldin, 2000). Because world development varies so widely, according to Hinrichsen (1999) there are large regional differences. In Africa, for example, an estimated 88% of all freshwater use is for agriculture, 7% for domestic purposes and 5% for industry. In Asia water also is used mostly for agriculture, estimated at 86% of total use, while industry accounts for 8% and domestic use, 6%. In Europe, however, most water use is for industry, at 54%, while agriculture accounts for 33% and domestic use, 13%.

While the analysis above gives percentage breakdowns of the various uses of water, in absolute terms, a country's level of water use strongly depends on its level of economic development. Furthermore, in developing regions, people use far less water per capita for personal use than in developed regions. According to UNDP (1994) in Africa annual per capita water withdrawals for personal use is only 47 litres of water per day and in Asia, 85 litres per day. In contrast, comparable water use in the UK is estimated at 334 l/pd and in the USA, 578-700 l/pd, (PAI, 1999). As to be expected, around the world freshwater demand per capita is rising as countries develop economically. These increasing withdrawals of water are reflected in all 3 major categories of use: rising industrial demand, rising domestic demand and increasing reliance on irrigation to produce food.

Again, as might be expected, the amount of water use also indicates the extent of urbanisation in a country. Low levels of water use in several developing countries indicate difficulty in obtaining freshwater, partly because piped water systems are uncommon in rural areas. According to PAI (1999) two-thirds of the world's population in developing countries get their water from public standpipes, community wells, rivers and lakes or rainfall collected off roofs. Often rural people, usually women and girls, walk several kilometres and spend several hours to bring water for their households and in Africa, for instance, such activity consumes 40 billion person-hours annually. This depresses the possibility of economic advancement.

So, water use significantly increases with development and urbanisation and this can be quantified. UNESCO (2003) reports that the average American household used as little as 10 m^3 of water per year in 1900 compared with more than 200 m^3 today. A century ago, most Americans lived in rural areas and obtained their freshwater from wells or public standpipes. Running water was not available to households except in large cities. In contrast, almost every American household today has running water and this water costs very little. This UNESCO report also shows that industrial use of water increases with national income, ranging from 10% for low- and middle-income countries to 59% for high-income countries, see Figure 8. This figure indicates the competing water users in the world, high and low and medium income countries.

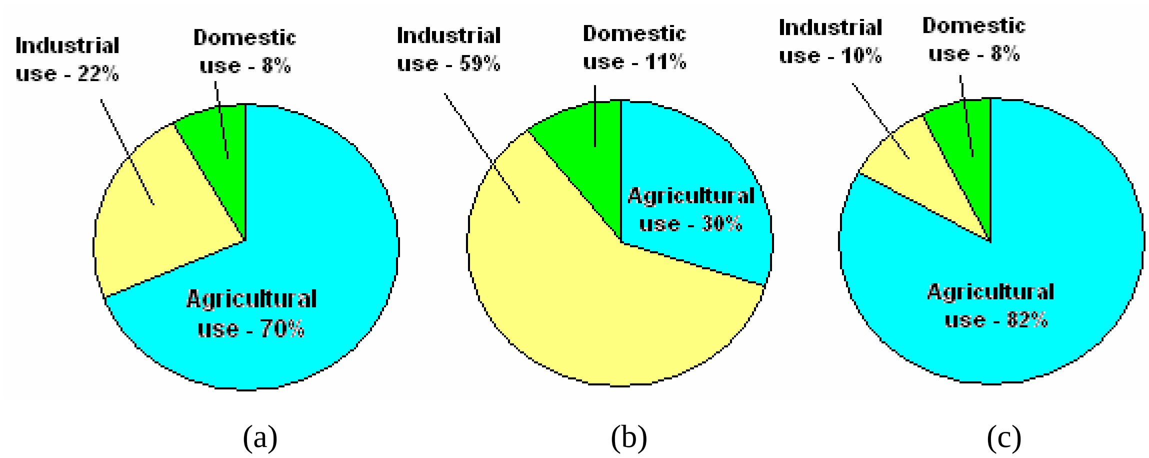

Figure 8. Competing water uses for (a) world, (b) high income countries and (c) low and medium income countries, (UNESCO, 2003).

According to McCartney (1999) 321 cities had population in excess of 1 million and there were 15 megacities with populations of 10-20 million in 1995. He estimates that by 2025, about 56% of population will be urban and there will be more than 30 megacities. A recent UNESCO (2003) report indicates that at present 48% of the world's population lives in towns and cities; by 2030 the proportion will rise to about 60% (nearly 5 billion people).

With this rapid increase in urbanisation, it will be difficult for cities to meet the rising demand for freshwater with agriculture at the same time becoming increasingly dependent on irrigation. Rapid urban growth in developing countries puts tremendous pressure on their old and inadequate water supply systems. According to WWC (2000), for example, Jakarta's water supply and disposal systems were originally designed for 500,000 people, but in 1985 the city had a population of nearly 8 million and today it is more than 15 million. The city suffers continuous water shortages and less than 25% of the population has direct access to water supply systems. The water level in the aquifer is now generally below sea level, and in some places as much as 30 metres below. Saltwater intrusion and pollution have largely ruined this as a source of drinking water. Jakarta's case shows that how urbanisation has resulted in a combination of water supply problems, each individually discussed in preceding sections of this chapter.

2.4. Water Shortage

Rapid population growth and increasing water consumption for agriculture, industry and municipalities have too heavily stressed the world's freshwater resources. It is not surprising that, in some areas the demand for water already exceeds nature's supply with a growing number of countries expecting to face water shortages in the near future, see Appendix A1.

Water shortage is becoming the greatest threat to food security, human health and natural ecosystems. Seckler (1999) points out there is an urgent need to focus the attention of professionals and policy makers on the problem of groundwater depletion and pollution, particularly in the more arid and semi-arid regions of the world like Asia and the Middle East. Moreover, these regions contain some of the major bread baskets of the world such as the Punjab and the North China plain. Brooks (1999) identifies the origin of water stress stemming from three interacting crises:

1. Quantity: the economic crisis - demands for freshwater exceed the naturally occurring, renewable supplies.
2. Quality: the ecological crisis - much of the limited water is being polluted from growing volumes of human, industrial and agricultural wastes.
3. Equity: the political crisis - the same water is desired simultaneously by different sectors within a single society or nation or by different countries wherever it flows (probably via a major river) through an international border.

Water quantity has been an issue since history began, but as mentioned previously, water quality is a new problem reaching crisis level in many regions. To a great extent, Brooks's (1999) third crisis has been caused by the other two and has now reached a level of concern in some regions. Because the three crises are interdependent, any resolution must simultaneously address all three (quantity, quality, and equity) if it is to be economically efficient, ecologically sustainable and politically acceptable. The physical and economical factors causing water resource stress are variation and uncertainty (due to geography and climate), demography (rapid population growth and urbanisation) and economy (the blooming of economic growth).

There are several measures of water availability such as per capita index (resource-to-population), criticality index (use-to-resource), consumption-to-supply index and social water scarcity index, (Schram, 1999, McCartney, 1999, Cosgrove, 2000 and Ohlsson, 2000). There is no universally adopted measure of water stress, but the most widely used is the Falkenmark indicator, (Serageldin, 2000), of renewable water resources per capita per year, on a national scale, see Table 1. This table shows the index of water per capita. She estimated a minimum need of 100 l/pd for household use and from 5 to 20 times as much for agricultural and industrial uses. Falkenmark's concepts have been widely accepted and used by hydrologists, the World Bank and other organisations. However, the Falkenmark indicator does not account for the temporal variability in water availability or for actual use. Its advantage is that the data are widely available.

Table 1. Index of water per capita, (Schram, 1999)

Renewable freshwater per capita (m^3/y)	Effects on country
> 1700	limited stress
1000 – 1700	water stressed
1000 – 500	water scarce
< 500	absolute scarcity

Brooks's equity crisis is becoming severe and widespread. Competition among water users in different sectors (industry, agriculture and municipality) is increasing in all countries. Tensions are expected to be very high in water-deficient areas where population pressures, urbanisation and development needs combine to create intense demand for limited freshwater resources.

The threat of regional conflicts over limited water supplies is rising in nearly all water-short areas. Cosgrove (2000) has identified over 200 rivers and lake basins bordered by 2 or more countries and aquifers crossing international borders. Hence, there is widespread potential for increased regional tensions over shared resources, particularly in arid and semi-arid regions where water is already scarce. At least 10 rivers flow through around half a dozen or more countries. Villiers (2005) points out several “hot spots”, namely, the Ganges River (between India and Bangladesh), the Nile (in Africa), the Jordan (between Israel and Jordan), the Tigris-Euphrates (shared by Turkey, Syria and Iraq), the Mekong (between Thailand and Vietnam), the Danube (between Czechoslovakia and Hungary), the Colorado (between Mexico and USA) and the Amu Darya and Syr Darya (in the Aral Sea Basin).

3. Solutions to Water Problem

Generally, there are two classes of solutions for water problems: increasing the supply of water (developing new resources) and/or decreasing the demand for water (managing available resources). According to Loucks (2000) everyone involved in water management and development has an obligation to assure that these systems should provide sufficient quantities and qualities of water at acceptable prices and reliabilities, while protecting the environment and preserving the biodiversity.

Buras (2000) defines the rationale of water resources projects and their subsequent management in terms of three essential principles:

1. The availability of water, its location, quantity, quality and existing institutional framework.
2. The demand for water/or water derivatives, expressed quantitatively for specific periods of time (seasons, months, weeks, etc.).

3. Cost, direct, indirect, or generated outside the service area of the project.

According to Duda (2000), in developing and using water resources, priority has to be given to the satisfaction of basic needs and safeguarding of ecosystems. Beyond these requirements, water uses should be charged appropriately. Savenije (2000), too, distinguished between primary water needs (basic human needs such as drinking, cooking and hygiene) and secondary needs (all other uses). The international consensus is that water for secondary purposes should be considered as an economic good, within which priorities in allocation should be based on socio-economic criteria, but could go as far as economic pricing, see Appendix A3.

3.1. Management of Water Resources

Kundzewicz (2000) discusses the need for water resources management in terms of supply and demand. His conclusion is, firstly, that development of new sources of water supply can largely be avoided by implementing intelligent water conservation and demand management programs, installing new efficient equipment and applying appropriate economic and institutional incentives to optimise water usage among competing groups. On the demand side, a variety of economic, administrative and community-based measures, he feels, can help conserve water immediately. He explains that while the links between population and freshwater resources are complex, there is no doubt that population growth increases the demand for freshwater. While new approaches to manage water supply and demand can help in the short term, reducing population growth is necessary to avoid a tragedy in the long term. There is an urgent need, he concludes, to slow population growth and to stabilise population size through family planning and reproductive health services. So the political crisis of Brooks is transformed by Kundzewicz into a political solution to the other crises, namely “rational” family planning.

In the UNESCO (2003) report, it is stated that a key component of non-structural approaches to water-resource management is a focus on using water more efficiently and reallocating more effectively among existing users. A general point made in the report is of considerable significance. It concludes that there is always great potential for better conservation and management, no matter how freshwater is used (for agriculture, industry or municipalities). According to the report, water is wasted nearly everywhere and until actual scarcity impacts, most people will continue to take access to freshwater for granted. Low water prices have hampered the introduction of water saving technologies and contributed to its overuse. Developed countries show a wide range of variation in their water pricing, ranging from 0.4 $\$/m^3$ in Canada, 1.18 $\$/m^3$ in the UK, to 1.91 $\$/m^3$ in Germany.

3.2. Development of Water Resources

According to Frederick (1999) water-resources development around the world has taken different forms and directions since the dawn of civilisation. Humans have long sought ways of reducing their vulnerability to irregular river flows and variable rainfall by moving, storing and redirecting natural waters. Early civilisations expanded in regions where rainfall and runoff could be easily and reliably tapped. He adds that the growth of cities required advances in civil engineering and hydrology as water supplies had to be brought from distant sources. In general, there are two classes of method for developing new sources of water supply:

1. The traditional approach to construct wells, dams, reservoirs, canals and pumps over the years to collect, control and contain excess flows and to distribute water on demand during different periods. They help to change the world's varying water resources into reliable and controlled supplies. As a result, most water users take for granted that unrestricted quantities of freshwater are instantaneously available to them on demand.

2. Un-conventional and exotic methods. Limited water availability and public resistance to the high financial and environmental costs of the traditional approaches have forced suppliers to consider alternative approaches such as

recycling wastewater and desalination together with more exotic schemes such as cloud seeding, fog collection and towing icebergs.

In Shiklomanov's (2000) analysis of recycling he states that it is now quite feasible to upgrade wastewater to meet standards for domestic use. Certainly wastewater recycling will become an increasingly important source of new water in the coming decades in many areas. Moreover, recycled water can be used to recharge groundwater aquifers, supply industrial processes, irrigate certain crops, or supplement potable supplies. According to Shiklomanov, in 1995 the wastewater volume rate was approximately $270x10^9$ m^3/y in Europe, $450x10^9$ m^3/y in North America, $850x10^9$ m^3/y in Asia, and $60x10^9$ m^3/y in Africa. There is a further key issue, the effect of wastewater. Every cubic metre of contaminated wastewater discharged into water bodies and streams makes 8 to 10 m^3 of pure water unsuitable. Shiklomanov argues, therefore, that recycling is advantageous not only in providing usable water but also in reducing pollution of existing supplies.

Most industrial and domestic processes do not require water of drinking standard. For example, there is no need to for domestic sanitary water to be of the same quality as drinking water. In view of the above discussion, it is hardly surprising that there must be a cost trade-off, because dual purpose water supplies need to be kept separate, increasing pipework expenses.

There has been a significant increase in the availability and use of treated wastewater for a wide range of applications in different parts of the world. As Gleick (1998) describes, the economics of recycling are determined by the environmental and health regulations that dictate how communities collect and treat wastewater. The true recycling cost is about \$0.35-\$0.40 per m^3 of water. As with the question of population growth, here political decisions can affect the cost to the consumer.

Of course, a key supply-side solution is provided by desalination. As Hoekstra (1998) points out, because the oceans are both the primary source and the ultimate sink of all water on earth, the possibility of obtaining freshwater from the oceans has no limitation, apart from those of energy requirements. Because of its importance, desalination is reviewed in detail in the next chapter.

To summarise the above arguments, water planners should consider both traditional and modern methods in the design and implementation of their projects. Local circumstances should determine the choice of method that is involving technologies that can be operated and maintained by local manpower.

4. Conclusions

Water is the source of life and development on our planet. Reliable assessment of the earth's water is very difficult due to the dynamic nature and hydrologic variability of water in time and space. Allied problems exist in estimating global population and total annual renewable freshwater availability internationally. There are some controversies among water scientists and policy makers over their analyses of water demand, availability and the nature of its scarcity. The latter issue requires the definition of water scarcity indicators which should consider all the renewable resources, the influence of climate and the different needs and distribution of water resources among immediately competitive users. However, the following conclusions can be safely drawn:

- The main water deficit regions of the world in the 21st century include most of Africa (except its central parts) and Asia (except Siberia), a large portion of the United States and Mexico, and parts of South America, Australia and Europe.
- North and South Africa, Middle East, central Asia, North China, western US, Northwest Mexico and East Australia are categorised as absolute water-scarce.

There is no single and simple solution to water problems. Applying the lessons learned from successful methods elsewhere (even allowing some modification) can greatly improve the effectiveness of water projects. For any water provision scenario, these steps should be followed in order of importance:

Firstly, identification and evaluation of water availability (both quantity and quality) and demand in any region or country.

Secondly, assessment and analysis of local and traditional methods of water provision. Local knowledge and traditional water supply technologies and management methodologies must be fully utilised.

Thirdly, applying the theory of "thinking globally and acting locally" in a specific condition or region by considering all management and development principles from efficient use of water to developing alternative sources of water supply. Capital is the main constraint in most of the developing world, and non-structural measures should be implemented whenever possible. Upgrading an existing system is often more cost effective than constructing a new one. Technology is another constraint, so the integration of local and modern techniques to determine an appropriate technology is essential and highly recommended such as development of simple small-scale solar desalination systems in remote areas of developing countries having safe drinking water problems and plenty of solar insolation.

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Appendix A1 - Population, Annual Renewable Freshwater Availability, 1950, 1995 and 2025 (PAI, 1997)

Country	Total Annual Renewable Freshwater Available (10^6 m^3)	1950		1995		2025	
		Population ($1x10^6$)	Per capita Water availability (m^3)	Population ($1x10^6$)	Per capita Water availability (m^3)	Population ($1x10^6$) Medium projection	Per capita Water availability (m^3)
Afghanistan	50	8.9	5 582	19.7	2 543	45.3	**1 105**
Albania	21.3	1.2	17 317	3.4	6 296	4.3	4 959
Algeria	14.8	8.8	1 691	28.1	**527**	47.3	**313**
Angola	184	4.1	44 541	10.8	17 012	25.5	7 202
Argentina	994	17.2	57 959	34.8	28 590	47.2	21 077
Armenia	13.3	1.4	9 801	3.6	3 654	4.2	3 171
Australia	343	8.2	41 733	17.9	19 198	23.9	14 333
Austria	90.3	6.9	13 021	8	11 224	8.3	10 873
Azerbaijan	33	2.9	11 388	7.5	4 379	9.7	3 395
Bahrain	0.09	0.12	776	0.56	**162**	0.86	**104**
Bangladesh	2 357	41.8	56 411	118.2	19 936	179.9	13 096
Barbados	0.05	0.21	237	0.26	**192**	0.29	**169**
Belarus	74	7.7	9 529	10.4	7 129	9.6	7 655
Belgium	12	8.6	1 447	10.1	**1 234**	10.3	**1 217**
Belize	16	0.07	231 884	0.21	75 117	0.38	42 667
Benin	25.8	2	12 610	5.4	4 770	12.3	**2 102**
Bhutan	95	0.73	129 428	1.8	53 672	3.6	26 056
Bolivia	300	2.7	110 538	7.4	40 464	13.1	22 847
Botswana	14.7	0.39	37 789	1.5	10 138	2.6	5 707
Brazil	6 950	53.9	128 763	159	43 707	216.6	32 087
Bulgaria	205	7.3	28 272	8.5	24 092	7.5	27 506
Burkina Faso	28	3.6	7 663	10.5	2 672	23.5	**1 194**
Burundi	3.6	2.5	1 466	6.1	**594**	12.3	**292**
Cambodia	498	4.3	114 611	10	49 691	16.9	29 317
Cameroon	268	4.5	60 009	13.2	20 315	28.5	9 397
Canada	2 901	13.7	211 181	29.4	98 667	36.4	79 731
Cape Verde	0.3	0.15	2 055	0.39	**777**	0.68	**442**
Cen. Africa	141	1.3	107 306	2.9	48 139	6	23 477
Chad	43	2.7	16 178	6.3	6 788	12.6	3 400
Chile	468	6.1	76 948	14.2	32 935	19.6	23 941
China	2 800	554.8	5 047	1 220	2 295	1 480	**1 891**
Colombia	1 070	11.9	89 570	35.8	29 877	52.7	20 316
Comoros	1.02	0.17	5 896	0.61	**1 667**	1.3	**760**
Congo	832	0.81	1 029 703	2.6	320 864	5.7	144 771
Costa Rica	95	0.86	110 209	3.4	27 745	5.6	16 940
Cote D'Ivoire	77.7	2.8	27 990	13.7	5 674	24.4	3 185
Croatia	61.4	3.9	15 948	4.5	13 629	4.2	14 471
Cuba	34.5	5.9	5 897	10.9	3 147	11.8	2 924
Cyprus	0.9	0.49	1 822	0.75	**1 208**	0.95	**947**
Czech Rep	58.2	8.9	6 521	10.3	5 671	9.6	6 045
Denmark	13	4.3	3 044	5.2	2 489	5.3	2 442
Djibouti	2.3	0.06	37 097	0.6	3 827	1.1	**2 028**
Dominican	20	2.4	8 500	7.8	2 557	11.2	**1 791**
Ecuador	314	3.4	92 707	11.5	27 400	17.8	17 644
Egypt	58.1	21.8	2 661	62.1	**936**	95.8	**607**
El Salvador	18.95	1.9	9 713	5.7	3 347	9.2	**2 055**
Equat. Guinea	30	0.23	132 743	0.4	75 000	0.79	37 594
Eritrea	8.8	1.1	7 719	3.2	2 775	6.5	**1 353**
Estonia	17.6	1.1	15 985	1.5	11 828	1.3	14 013
Ethiopia	110	18.4	5 967	56.4	1 950	136.3	**807**

Appendix A1 (continued)

Country	Total Annual Renewable Freshwater Available (10^6 m^3)	1950		1995		2025	
		Population ($1x10^6$)	Per capita Water availability (m^3)	Population ($1x10^6$)	Per capita Water availability (m^3)	Population ($1x10^6$) Medium projection	Per capita Water availability (m^3)
Fiji	28.6	0.29	98 789	0.78	36 416	1.2	24 402
Finland	113	4	28 187	5.1	22 126	5.3	21 345
France	198	41.8	4 734	58.1	3 408	60.4	3 279
Gabon	164	0.47	349 680	1	152 416	2.1	77 432
Gambia	8	0.29	27 211	1.1	7 201	1.9	4 032
Germany	171	68.4	2 501	81.6	2 096	80.9	**2 114**
Ghana	53.2	4.9	10 857	17.3	3 068	36.3	**1 464**
Greece	58.7	7.6	7 752	10.5	5 610	10.1	5 822
Guatemala	116	2.9	39 070	10.6	10 922	21.7	5 354
Guinea	226	2.6	88 627	7.3	30 752	15.3	14 785
Guinea-Bissau	27	0.5	53 465	1.1	25 257	1.9	14 055
Guyana	241	0.4	569 740	0.83	290 361	1.1	216 338
Haiti	11	3.3	3 373	7.1	**1 544**	12.5	**879**
Honduras	63.4	1.4	45 942	5.7	11 213	10.7	5 950
Hungary	120	9.3	12 851	10.1	11 874	8.7	13 846
Iceland	168	0.14	1 174 825	0.27	624 535	0.34	500 000
India	2 085	357.6	5 831	929	2 244	1 330	**1 567**
Indonesia	2 530	79.5	31 809	197.5	12 813	275	9 190
Iran	117.5	16.9	6 947	68.4	1 719	128.3	**916**
Iraq	109.2	5.2	21 171	20.1	5 434	41.6	2 625
Ireland	50	2.9	16 841	3.5	14 100	3.7	13 430
Israel	2.15	1.3	1 709	5.5	**389**	7.9	**270**
Italy	167	47.1	3 545	57.2	2 919	51.7	3 227
Jamaica	8.3	1.4	5 916	2.5	3 363	3.4	2 463
Japan	547	83.6	6 541	125.1	4 374	121.3	4 508
Jordan	1.71	1.2	1 382	5.4	**318**	11.9	**144**
Kazakhstan	169.4	6.7	25 272	16.8	10 073	20	8 450
Kenya	30.2	6.3	4 820	27.2	**1 112**	50.2	**602**
Kuwait	0.16	0.15	1 053	1.7	**95**	2.9	**55**
Kyrgyzstan	61.7	1.7	35 460	4.5	13 834	5.9	10 370
Laos	270	1.8	153 846	4.9	55 305	10.2	26 465
Latvia	34	1.9	17 445	2.5	13 407	2.1	16 129
Lebanon	5.58	1.4	3 867	3	1 854	4.4	**1 261**
Lesotho	5.2	0.73	7 084	2	2 565	4	**1 290**
Liberia	232	0.82	281 553	2.1	109 279	6.6	35 296
Libya	0.6	1	583	5.4	**111**	12.9	**47**
Lithuania	24.2	2.6	9 427	3.7	6 478	3.5	6 873
Luxembourg	5	0.29	16 892	0.41	12 285	0.47	10 730
Madagascar	337	4.2	79 688	14.9	22 657	34.5	9 775
Malawi	18.7	2.9	6 491	9.7	1 933	20.4	**917**
Malaysia	456	6.1	74 632	20.1	22 642	31.6	14 441
Mali	67	3.5	19 034	10.8	6 207	24.6	2 726
Malta	0.03	0.31	96	0.37	**82**	0.42	**71**
Mauritania	11.4	0.83	13 818	2.3	5 013	4.4	2 566
Mauritius	2.2	0.49	4 462	1.1	1 970	1.5	**1 485**
Mexico	357.4	27.7	12 885	91.1	3 921	130.2	2 745
Moldova	13.7	2.3	5 852	4.4	3 088	4.9	2 814
Mongolia	24.6	0.76	32 326	2.5	9 988	4.1	6 071
Morocco	30	8.9	3 351	26.5	**1 131**	39.9	**751**
Mozambique	208	6.2	33 559	17.3	12 051	35.4	5 868

Appendix A1 (continued)

Country	Total Annual Renewable Freshwater Available (10^6 m^3)	1950		1995		2025	
		Population ($1x10^6$)	Per capita Water availability (m^3)	Population ($1x10^6$)	Per capita Water availability (m^3)	Population ($1x10^6$) Medium projection	Per capita Water availability (m^3)
Myanmar	1 082	17.8	60 677	45.1	23 988	67.6	15 996
Namibia	45.5	0.51	89 041	1.5	29 622	2.9	15 172
Nepal	170	7.9	21 623	21.5	7 923	40.6	4 192
Netherlands	90	10.1	8 899	15.5	5 813	16.1	5 576
New Zealand	327	1.9	171 384	3.6	91 828	4.9	67 036
Nicaragua	175	1.1	159 381	4.1	42 445	7.6	22 909
Niger	32.5	2.4	13 542	9.2	3 552	22.4	**1 452**
Nigeria	280	32.9	8 502	111.7	2 506	238.4	**1 175**
North Korea	67	9.5	7 062	22.1	3 032	30	2 230
Norway	392	3.3	120 061	4.3	90 489	4.7	84 084
Oman	1.93	0.46	4 232	2.2	**874**	6.5	**295**
Pakistan	468	39.5	11 844	136.3	3 435	268.9	**1 740**
Panama	144	0.86	167 442	2.6	54 732	3.8	38 105
Papua New Guinea	801	1.6	496 590	4.3	186 236	7.5	106 149
Paraguay	314	1.5	211 022	4.8	65 037	9.4	33 565
Peru	40	7.6	5 241	23.5	**1 700**	35.5	**1 126**
Philippines	323	20.9	15 390	67.8	4 761	105.2	3 071
Poland	56.2	24.8	2 264	38.6	1 458	39.9	**1 406**
Portugal	69.6	8.4	8 281	9.8	7 091	9.4	7 374
Qatar	0.05	25	2 000	0.55	**91**	0.78	**64**
Romania	208	16.3	12 752	22.7	9 152	21.1	9 859
Russia	4 498	102.2	44 015	148.5	30 298	131.4	34 233
Rwanda	6.3	2.1	2 972	5.2	**1 215**	12.9	**485**
Saudi Arabia	4.55	3.2	1 421	18.3	**249**	42.4	**107**
Senegal	39.4	2.5	15 760	8.3	4 740	16.9	2 332
Sierra Leone	160	1.9	82 305	4.2	38 141	8.2	19 512
Singapore	0.6	1	587	3.3	**180**	4.2	**142**
Slovak	30.8	3.5	8 894	5.3	5 770	5.5	5 632
Solomon	44.7	0.1	496 667	0.38	118 254	0.84	52 962
Somalia	13.5	3.1	4 395	9.5	**1 422**	23.7	**570**
South Africa	50	13.7	3 654	41.5	**1 206**	71.6	**698**
South Korea	66.1	20.4	3 247	44.9	**1 472**	52.5	**1 258**
Spain	111.3	28	3 974	39.6	2 809	37.5	2 968
Sri Lanka	43.2	7.7	5 626	17.9	2 410	23.9	**1 805**
Sudan	154	9.2	16 757	26.7	5 766	46.9	3 287
Suriname	200	0.22	930 233	0.43	468 384	0.61	330 579
Swaziland	4.5	0.26	17 045	0.86	5 251	1.7	2 687
Sweden	180	7	25 663	8.8	20 482	9.5	18 925
Switzerland	50	4.7	10 652	7.2	6 977	7.6	6 595
Syria	53.69	3.5	15 362	14.2	3 780	26.3	**2 041**
Tajikistan	101.3	1.5	66 123	5.8	17 382	9.7	10 393
Tanzania	89	7.9	11 286	30	2 964	62.4	**1 425**
Thailand	179	20	8 946	58.2	3 073	69.1	2 591
Togo	12	1.3	9 029	4.1	2 938	8.8	**1 370**
Trinidad & Tobago	5.1	0.64	8 019	1.3	3 963	1.7	3 014
Tunisia	3.9	3.5	1 105	8.9	**434**	13.5	**288**
Turkey	193.1	20.8	9 280	60.8	3 174	85.8	2 251
Turkmenistan	72	1.2	59 455	4.1	17 669	6.5	11 128
Uganda	66	4.8	13 860	19.7	3 352	44.9	**1 467**
Ukraine	231	36.9	6 259	51.8	4 463	45.9	5 024

Appendix A1 (continued)

Country	Total Annual Renewable Freshwater Available (km^3)	1950		1995		2025	
		Population ($1x10^6$)	Per capita Water availability (m^3)	Population ($1x10^6$)	Per capita Water availability (m^3)	Population ($1x10^6$) Medium projection	Per capita Water availability (m^3)
United Arab Emirates	1.99	0.1	28 471	2.2	**902**	3.3	**604**
UK	71	50.6	1 403	58.1	**1 222**	59.5	**1 193**
USA	2 478	157.8	15 702	267.1	9 277	332.5	7 453
Uruguay	124	2.2	55 382	3.2	38 920	3.7	33 586
Uzbekistan	129.6	6.3	20 526	22.8	5 694	36.5	3 551
Venezuela	1 317	5.1	258 539	21.8	60 291	34.8	37 872
Viet Nam	376	29.9	12 553	73.8	5 095	110.1	3 415
Yemen	5.2	4.3	1 205	15	**346**	39.6	**131**
Zaire	1 019	12.2	83 634	45.5	22 419	105.9	9 620
Zambia	116	2.4	47 541	8.1	14 355	16.2	7 177
Zimbabwe	20	2.7	7 326	11.2	1 787	19.3	**1 034**

Appendix A2 - Better Drinking Water on Tap

(http://news.bbc.co.uk/1/hi/england/london/3051923.stm)

Wednesday, 9 July, 2003, 08:09 GMT 09:09 UK

BBC News

London has one of the highest standards of drinking water in the country, according to new figures from the water watchdog.

The Drinking Water Inspectorate (DWI) says the standard of tap water in England and Wales is at an all-time high.

In London, of 542,555 tests carried out by Thames Water 99.92% met the DWI's standards.

But the DWI also wants to improve customer satisfaction over the appearance and taste of tap water. The DWI's Milo Purcell told BBC London: "Although technically the water quality is very good, people are concerned about the aesthetic quality of the water.

"We would like hear from them if they have a problem with the taste and odour. We really want to try and fix that."

'Waste of money'

Market research has found that people do feel tap water is safe but the sales of bottled water are rocketing. Mr Purcell said people are wasting their money.

"I think people realise that cost-wise it makes no sense to spend money on expensive alternatives. Why do you want to pay all that money when the quality out of the tap is so good?"

In 2002 the number of tests failing to meet drinking water standards was only 3,741, compared to nearly 37,000 ten years ago.

Appendix A3 – Ministerial Declaration on Water Security in the 21st Century

Ministerial Declaration on Water Security in the 21st Century

Some 120 ministers of water attending the Second World Water Forum held at The Hague in March 2000 adopted a declaration aimed at achieving world water security. The declaration noted the following as the main challenges of this new century:

- **Meeting basic needs:** to recognize that access to safe and sufficient water and sanitation are basic human needs and are essential to health and well-being, and to empower people, especially women, through a participatory process of water management.
- **Securing the food supply:** to enhance food security, particularly of the poor and vulnerable, through the more efficient mobilization and use, and the more equitable allocation of water for food production.
- **Protecting ecosystems:** to ensure the integrity of ecosystems through sustainable water resources management.
- **Sharing water resources:** to promote peaceful cooperation and develop synergies between different uses of water at all levels, whenever possible, within and, in the case of boundary and transboundary water resources, between states concerned, through sustainable river basin management or other appropriate approaches.
- **Managing risks:** to provide security from floods, droughts, pollution and other water-related hazards.
- **Valuing water:** to manage water in a way that reflects its economic, social, environmental and cultural values for all its uses, and to move towards pricing water services to reflect the cost of their provision. This approach should take account of the need for equity and the basic needs of the poor and the vulnerable.
- **Governing water wisely:** to ensure good governance, so that the involvement of the public and the interests of all stakeholders are included in the management of water resources.

Source: World Water Forum 2000