VAGARIES OF THE DISTRIBUTION OF WATER ON THE EARTH: SO MUCH, TOO LITTLE FOR THE HUMAN RACE (THE GEOGRAPHY'S PERSPECTIVE)

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ABSTRACT:

Before the 19th century, there were limited problems with respect to water shortages or water stress. However, within the 20th and the early part of this 21st century, in both developed and developing countries, there is growing disparity between the available supplies and the ever-increasing demands for water. Several organizations have predicted extensive shortage of water supply (the organization for economic co-operation and development, 2012; World Bank, 2012). This anticipated shortages or water stress is dependent on the ever-increasing population. It is expected that by2050 world population will reach 9 billion (United Nations, 2000). This shortfall in supply is the critical dilemma concerning the earth's water resources and their use by the human race. This is the critical problem facing man kind today, especially those in the developing countries. Based on this, the paper examines the variable distribution of water resource on the earth. The paper further concludes that man kind is faced with the problem of water shortages. As a result of this conclusion, the paper recommends various measures that can be taken to advert the havoc this shortage could bring.

Keywords: Vagaries, Variability, Water, Resources, Earth and Human Race.

Introduction

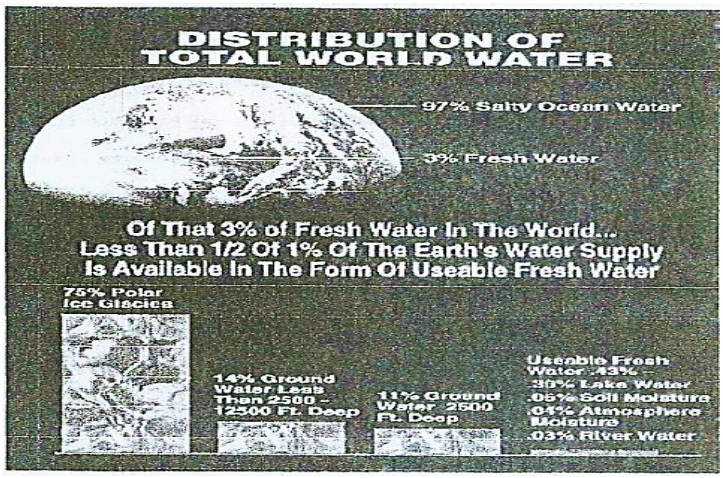
Water, the precious liquid that sustains life is highly abundant on the earth surface. Though very much available, its availability to man remains a big problem. Water changes form, moving from solid, liquid to gaseous states. Its constant circulation on its own is a problem that hinders its availability to man over space and time. The continuous cycling of water through the hydrological cycle renders the availability of water to man very difficult at certain points in time, while at certain points it is excess.

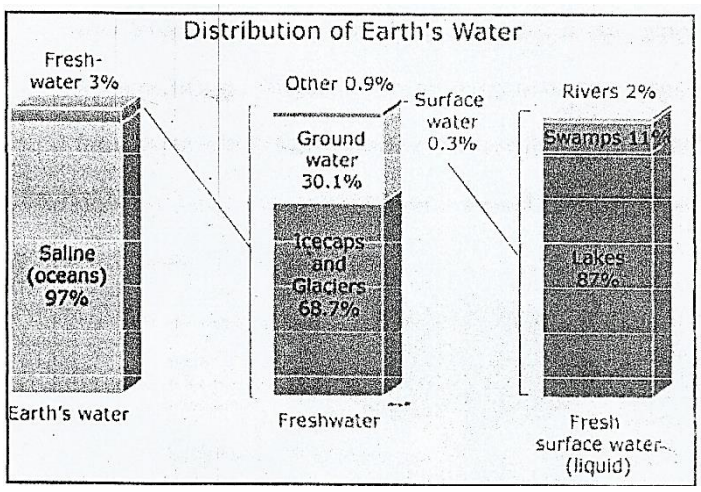
While 70 per cent of the world's surface is covered by water, 97.5 per cent of that is salt water. Of the remaining 2.5 per cent that is freshwater, almost 68.7 per cent is frozen in ice caps and glaciers. Only one per cent of the total water resources on

earth is available for human use.(UN-WWAP, 2006). The UN World Water Programme in2005 estimated that by 2025, about 2/3 of the world's population - about 5.5 billion people –will live in areas facing moderate to severe water stress (UN, 1997: 19).

Where is Earth's water located and in what forms does it exist? We can see how water is distributed by viewing Figures 1 and 2.

Spatial Distribution of Water of the Face of the Earth.





The left-side bar (Fig. 2) shows where the water on Earth exists; about 97 percent of all water is in the oceans. The middle bar shows the distribution of that three percent of all Earth's water that is fresh water. The majority, about 69percent, is locked up in glaciers and icecaps, mainly in Greenland and Antarctica. You might be surprised that of the remaining fresh water, almost all of it is below your feet, as ground water. No matter where on Earth you are standing, chances are that, at some depth, the ground below you is saturated with water. Of all the freshwater on Earth, only about 0.3 percent is contained in rivers and lakes – yet rivers and lakes are not only the water we are most familiar with, it is also where most of the water we use in our everyday lives exists (Fig.3).

==== **Vagaries of the Distribution of Water on the Earth** ====

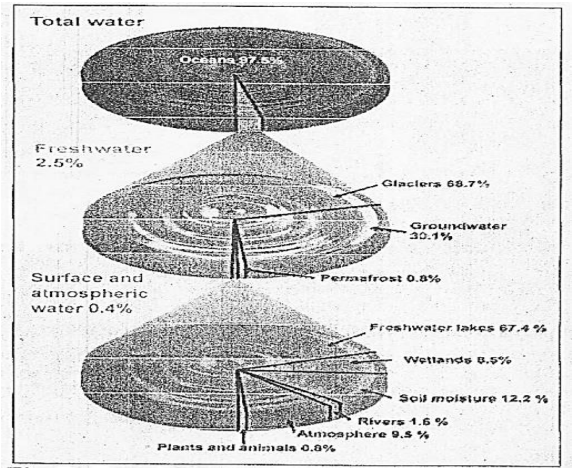


Fig 3: Fresh water Distribution on earth

Of the world's total water supply of about 333 million cubic miles (1,386 million cubic kilometers) of water, over 96% is saline. Also, of the total freshwater, over 68 percent is locked up in ice and glaciers. Another 30 percent of fresh water is in the ground. Thus, surface-water sources(such as rivers) only constitute about 22,300 cubic miles (93,100 cubic kilometers), which is about 0.0067 percent of total water, yet rivers are the source of most of the water people use.

Table 1: An estimate of global water distribution

Water source	Water Volume, in cubic miles	Water volume, in cubic kilometers	Percent of freshwater	Percent of total water
Oceans, Seas, & Bays	321,000,000	1,338,000,000	–	96.5
Icecaps, Glaciers, & Permanent Snow	5,773,000	24,064,000	68.7	1.74
Ground water	5,614,000	23,400,000	–	1.7
Fresh	2,526,000	10,530,000	30.1	0.76
Saline	3,088,000	12,870,000	–	0.94
Soil Moisture	3,959	16,500	0.05	0.001
Ground Ice & Permafrost	71,970	300,000	0.86	0.022
Lakes	42,320	176,400	–	0.013
Fresh	21,830	91,000	0.26	0.007
Saline	20,490	85,400	–	0.006
Atmosphere	3,095	12,900	0.04	0.001
Swamp Water	2,752	11,470	0.03	0.0008
Rivers	509	2,120	0.006	0.0002
Biological Water	269	1,120	0.003	0.0001

Source: **Igor Shiklomanov's chapter** "World fresh water resources" in Peter H. Gleick (editor), 1993. Oxford university press, New York.

Surface Water: Rivers and streams constitute an important component in the global water system. They contribute an annual total discharge of between 29,500km^3 and 36,300km^3 from the land areas to the sea (Hammond, 1990), and those discharges vary from one continent to the other as shown on Table 2.

TABLE 2: Summary of River Discharges From Land Areas to The Sea

LAND REGION	AREA ($Km^2 x10^{-3}$)	MEAN DISCHARGE ($m^3 5^{-1} x10^{-3}$)
Europe Including Iceland	7,960	75.0
Asia and East Indias	31,500	226.00
Africa	18,700	105.4
North America	21,400	151.4
South America	17,000	353.00
Australia, Including Tasmania And New Zealand	5,380	13.3
Green Land	2,180	12.4
Total	**140,120**	**936.5**
Equivalent Annual Volumn	**29,500km^3**	

Source: Word, R.C. and Rabbinson (1990)

The Abundance and Scarcity of Water Resources.

As a very dynamic resource which is subjected to constant changes in its form, it's quantity and quality over space and time; water is abundant and scarce because of a number of reasons, which include; climatic oscillations which induces floods in one part of the globe (excesses)and drought in another part (shortage), geological setting of an environment which determines the level of aquifer recharge and the extent to which water will be available at the surface or below (as in the case of a pseudo-karst or avolcano karst), the geology too will determine the water quality through its ability to block the flow of leachate and other contaminants and above all, the role of man in his waste disposal introduces pollution and reduces the quality of water. This situation is very much akin to what occurred in the Soviet Union in which the water was contaminated to a very high degree. And so, Lambi (2009) uses the Rime of the Ancient Mariner in the Coleridge's verse "***Water water everywhere not a single drop to drink"*** to describe the situation. This is a very clear situation of abundance and scarcity at the same time.

There is a transitional zone of non-saturation between the soil moisture belt and the underlying water table. By non-saturated flow, water percolates below the root zone (soil moisture zone) and migrates towards the water table. Before the water table is the Vadose zone and the water in the Vadose zone is called the

Vadose water. The average thickness of this zone of vadose water is unknown. Conservative water (soil moisture) could be removed either by evaporation and transpiration (or evapotranspiration) from the soil and vegetation surface or it could be removed from the soil moisture zone by downward percolation to form the underlying groundwater. Through this way, vegetation water contributes to the global water system.

Spatial Distribution and Availability of Water Resources

According to Wilson (1990) and Shiklomanor (1993), the surface area of the earth is $510x10^6Km^2$ of which $362x10^6Km^2$ (71%) is covered by water. This means that ¾ of the earth's surface is covered by water. The earth can thus be said to be a watery planet. If this is true, then, why do we worry about water supply since it is abundant, renewable and plentiful. The problem starts when we look at how the waters of the earth are distributed (Table 3)

Location	**Volumn ($100Km^3$)**	**% of Total Water**	**Estimate Average Resident Time of Water**
Fresh water Lakes	125	0.009	Tens of years
Rivers	1.25	0.00009	2 week
Soil Moisture	65	0.0047	
Ground water	8,250	0.6066	Hundreds of Thousand of years
Salt water Lakes/ Inland Seas	105	0.0077	Tens of years Water Vapour (water
Equivalent of it)	13	0.0009	9 days
Ice caps and Glaciers	29,200	2.147	Tens of thousands of years or longer
Oceans and Seas	1,320,000	97.058	Thousand of years
		100	

Source: Wilson (1990)

From Table 3, we observe that more than 97% of the earth's water is in the oceans and seas, and the next largest storage compartment, the ice caps and glaciers, accounts for another 2%.Together the oceans and seas, and ice caps and glaciers tie up more than 99% of the total water of the earth. This means that less than 1% is available as fresh water.

The implication of Table 3 is obvious to man. We cannot use ocean/sea water because of high Salinity neither can we use water from the ice caps and glaciers because they are frozen. Also, water from the salt water lakes and inland seas are salty and not good for human use. We cannot control and collect the water vapour in the atmosphere anytime we want. It is worthy to

note that it is fascinating that only 0.0009% (approximately 0.001%)of the total water on earth is in the atmosphere at any one time.

Uneven distribution of an abundant resource such as water generates the problem of scarcity. Scarcity comes up because some areas have more than enough water in terms of quantity (but not necessarily quality), while others are merely struggling to have something to drink. The Polar Ice caps for instance, have abundant freshwater supplies stored in the form of ice which could serve a greater part of the earth, while the Arid Regions are barely depending on the few available oases to get potable water. A possible medium for redistribution could reduce the controversy that surrounds water abundance and scarcity at the same time. Factors such as climate, geology and human and industrial activities should be used to show the problems of water abundance and scarcity at the same time. It should be noted that abundance can be viewed from two main perspectives; the perspective of quantity and that of quality. Quality is very crucial because water, health and sanitation go hand in hand.

Climate

Climatic conditions prevailing on a spatiotemporal basis determines the availability of water on the planet today. These climatic changes have led to water stress in some areas and water abundance in others. All regions of the world show an overall net negative impact of climate change on water resources and freshwater eco systems. Areas in which runoff is projected to decline are likely to face a reduction in the value of the services provided by water resources. The beneficial impacts of increased annual runoff in other areas are likely to be tempered in some areas by negative effects of increased precipitation variability and seasonal runoff shifts on water supply, water quality and flood risks (IPCC, 2007).

The future effects of climate change on water resources in the world will depend on trends in both climatic and non-climatic factors. Evaluating these impacts is challenging because water availability, quality and stream flow are sensitive to changes in temperature and precipitation. Other important factors include increased demand for water caused by population growth, changes in the economy, development of new technologies, changes in watershed characteristics and water management decisions.

Water is the key medium that links atmospheric temperature increases to changes in human and physical systems. Climate change alters the hydrological cycle, resulting in water scarcity in one part of the world

and abundance in another. The trigger is the warming of the atmosphere and oceans, which will change major weather systems. This will alter the temporal and spatial patterns of rainfall with consequences for runoff, surface and groundwater storage, river flow regimes and, it is estimated, greater likelihood of extremes – droughts and floods – indifferent parts of the world (Alan Nicol and Nanki Kaur 2009).

Of the 19 countries around the world currently classified as water-stressed, more occur in Africa than any other continent (Watson et al. 1997).In 1994, available freshwater resources in Africa were about 4,050 km^3 per year, representing about 9% of the world's total and about5.7 thousand m^3 per capita per year, against a global mean of 7.6 thousand m^3 per capita per year (Shiklomanov,1996). These resources are not uniformly distributed, Eastern and Southern Africa having 3.87 and 4.8 m^3 percapita per year respectively, the Sahel region having only2.2 of m^3 per capita per year.

According to Shiklomanov (1996), rainfall is highly variable and a number of countries have experienced droughts since the 1970s which have led to a general decrease in river discharges, and a consequent reduction in lake areas. For example, the Lake Chad is now 5% of its former size 35years ago. A drop in the water level in reservoirs and rivers could adversely affect the quality of water by concentrating sewage and industrial effluents, thereby exacerbating water-borne diseases and reducing the quality and quantity of fresh water available for domestic use (Dixon et al,2003). This is additional stress in a continent where a sizeable portion of the population is without adequate water and sanitation coverage, particularly in the rural areas (Nyong A. 2005).

Geology

The geological setting of the world accounts for the scarcity and abundance at the same time. In other words, while people cry of scarcity in a pseudo- karst landscape for instance, water is buried underneath the rocks(aquifers). In parts of the United States, China and India, ground water is being consumed faster than it is being replenished, and groundwater tables are steadily falling. Some rivers, such as the Colorado River in the western United States and the Yellow River in China, often run dry before they reach the sea.

The Nigerian Situation

Usually water supply problem in Nigeria vary with the geology, the environment and the life style of the local people. Both surface and groundwater sources are limited and depleted. Recent development projects in the Chad basin and within Borno, Gombe and Yobe states have revealed that 2 out of 3 productive aquifers in the area have already been exhausted (Chima, et al, 2007). Drought has ravaged parts of the northern Nigeria so much that the Emir of Katsina, Alhaji Kabir Usman, once appealed to the Federal Government to consider "channeling sea water to this part of the country as a matter of urgent priority". The Emir's plea for seawater which in any event is salt water and as such of little use to agriculture, shows that the situation is critical and approaching danger point. Special efforts must thus be made to explore more water bearing aquifers in this region. The issue of pipe rust, iron and salt water contamination is well-known in Borno, Gombe and Yobe states, especially in the case of wells tapping the middle zone aquifer of the Chad formation in the Bornu and Dikwa Emirates.

Human Activities

The urban centers in Nigeria are not left out of this water supply malaise. In most urban communities, the taps are perennially dry. Most times, the street traders, who wrestle with garbage heaps in their frantic attempt to escape from urban council officials, cannot find water to clean up themselves and the delicacies they peddle. Water supply shortages in urban areas are assuming dangerous dimensions. Scarcity of water has made many urban dwellers in Nigeria to consume all water supplied to the house, no matter the source. At times. the water available is not enough to service core needs such as toilet flushing and house cleaning. This maybe the reason for the high incidence of water borne and water related diseases ravaging our urban areas especially among the poor (Ezenwaji, 2017). Such diseases usually include cholera, typhoid fever, diarrhea, dysentery and so on.

According to Ezenwaji (2017), in Anambra state, ample and verifiable evidence abounds to show that there are acute water supply problems in urban areas. In Onitsha urban area, the story of water supply is that of woes, as many inhabitants of the city fetch water from surface water bodies mainly Nkisi and Idemili rivers, both of them heavily polluted because they serve as receptacles of wastes (Ezenwaji, 2010, 2017, Ugwu 2012 and Uraeze, 2014). Again, apart from the obvious poor water quality content of sources, people trek great distances to even fetch water from them.

==== **Vagaries of the Distribution of Water on the Earth** ====

Since the advent of industrial and revolutions, economic indicators have been considered as the principal criteria for measuring progress. The industrial and technological progress however, has been accompanied by a growing negative impact on the environment in terms of its pollution and degradation. Industrialization carries with it the seeds of environmental damage, assisted and abetted by both needs and greed of man. Freshwater ecosystems have been severely degraded: it is estimated that about half the world's wetlands have been lost, and more than 20 per cent of the world's 10,000 known freshwater species have become extinct, threatened or endangered (UN-DESA: 10).

Activities such as manufacturing, processing, transportation and consumption not only deplete the stock of natural resources but also add stress to the environmental system by accumulating the stock of wastes. The productivity of the industries, however, depends on the supply and quality of natural and environmental resources. While water, soil, air, forest and fishery resources are productive assets, the pollution of water, air, atmosphere and noise are the by-products of economic development, particularly industrialization and urbanization. "Green-house effects", "global warming" and "acid precipitation" are cases in point. Pollution is an "external cost" (sometimes called a "spill-over cost" or a "neighborhood cost"), Untreated or improperly treated waste becomes pollution, increasing not only private costs but also social costs. According to Barry Commoner, solving the problem of waste disposal creates a new one – pollution.

Water Quality

Water is a universal solvent, dissolving virtually every substance that comes its way. This attribute is of course not good as it threatens the quality of water available to man at a particular point in time. Human and industrial wastes have all been pumped into fresh and saline water ecosystems. Fresh and potable water depletion has been on the increase in the later part of the 20th century and it is intensifying in this century. As fresh water sources transform into waste receptacles, so too has there been a question on water availability for consumption to man. The United States Environmental Protection Agency (USEPA)estimates that 35 million tons of dangerous solid or liquid wastes per year is produced in the U.S alone which must bere-deposited to the earth, or burned, but most is buried on land and 44% of such wastes may infiltrate to the ground tocontaminate ground water which is more than what we have on the surface.

Industrial water pollution has been a major concern in the Former Communist Soviet Union. The doctrine of communism made the Soviets to believe that

they were drinking the best water and eating the best foods on the planet. However, it was after the Chernobyl Disaster of1986 and the consequent opening up of the Communist Society to the World (Gorbhachev, sglasnoit and perestroika policy) that made communist to realize that they were actually drinking a highly polluted water source.

The situation of Japan comes to mind in discussions on water pollution. Japan, an Island in the borders of the Pacific was faced with a situation of near obliteration of her two important cities; namely, Hiroshima and Nagasaki. After the war, Japan embarked on massive industrial expansion without considering the environmental implication of industrial wastes on land, air and most importantly, water. Industrial water pollution created a very tragic incident in the Town of Minamata.

According to Luoma (1984), in the 1950's in Minamata (Japan), large quantities of untreated wastes which were highly concentrated with mercury, affected underground water which flowed to the streams as methyl-mercury and destroyed aquatic life. A high concentration of mercury was found mostly in shellfish which after consumption led to deformation especially of children and other health hazards. Hence in Japan today, the name Minamata does not only mean a town, but also denotes the name or a disease. This shows the extent to which industrial activities would render water useless for consumption and increase the vulnerability of man to water related diseases.

Every week an estimated 42,000 people die from diseases related to low quality drinking water and lack of sanitation. Over 90 per cent of them occur to children under the age of 5 (WHO/UNICEF, 2005:15). These are all evidence that water pollution has rendered fresh water useless in some parts of the world and continue to do so. Worthy of note too is the fact that agricultural areas and the excessive application of fertilizers and chemical pollute surface and ground water sources too.

According to the World Health Organization (WHO, 2005),two of the water-related diseases, diarrhea and malaria, ranked 3rd and 4th place in the cause of death among children under 5 years old, accounting for 17 per cent and8 per cent respectively of all deaths. If increases insanitation coverage stay as low as between 1990 and 2002, the world will fall short of its MDG target by over half a billion people by 2015 (WHO/UNICEF, 2005). In 2002, 2.6billion people -roughly 42 per cent of the world's population - had no access to improved sanitation facilities. An additional 1.8 billion people need to be provided with improved sanitation from 2002 to 2015 to achieve the MDG to halve the proportion unserved in 1990. Even if that target is achieved, still 1.8 billion people will lack adequate sanitation in 2015 due to population increase(WHO/UNICEF 2005).About 90 per cent of sewage and 70per cent of industrial wastes in developing countries are discharged into water courses without treatment, often polluting the usable water supply.

Water scarcity forces people to rely on unsafe sources of drinking water. It also means they cannot bathe or clean their clothes or homes properly. Poor water quality can increase the risk of such diseases like diarrhea, cholera, typhoid fever

and dysentery, and other water-borne infections. Water scarcity can lead to diseases such as trachoma (an eye infection that can lead to blindness), plague and typhus. Figure 4 shows a woman and child fetching an abundant but scarce (polluted) resource in Nepal.

Figure 4: People in Nepal are forced to Use polluted water sources (Notice water colour)

The way forward:

- In order to ensure water sufficiency both in quality and quantity, it will be necessary to understand the geology of an area especially to know the capacity of ground water recharge by aquifers. At the same time, to avoid see page which will cause the proliferation of water borne diseases through pollution. No doubt, it is estimated today that more than 1.5billion people do not have access to safe and secured (potable) water. Therefore, in line with the Millennium Development Goals which was supposed to be attained in 2015, we need to understand the nature of our environment and the geology so as to save humanity from the scourge of water borne diseases since water is life.

- In addition to the typical impacts on water management, climate change introduces an additional element of uncertainty about future water resource management. Strategies have been developed and continue to evolve to address these issues. Implementation of adaptation measures, such as water conservation, use of markets to allocate water, and the application of appropriate management practices will have an important role to play in determining the impacts of climate change on water resources.

- Based on all the discussion above, the following suggestions could be used to salvage the situation.

i. **Proper and Efficient River Basin Management:** Subjecting our water bodies to over-extraction and pollution inevitable leads to the destruction of aquatic systems and everything dependent on them. Water cannot be considered in isolation, as it is at the core of all aspects of human economy and society. The sustainability of water resources and of all life is dependent upon human activities. We need to protect and clearly manage the river basins from environmental degradation and deterioration because all the actions that cause water scarcity are all man induced not nature.

ii. **Rainwater Harvesting:** Nigeria has a tropical climate with variable rainy and dry seasons. The Southern parts of Nigeria generally have more rainfall amounts than the Northern section. In these areas with high rainfall amounts, rainwater harvesting should be vigorously pursued especially in those areas with difficult geology and in tropical regions.

iii. **Community Involvement and Participation:** When a village/community is selected for water supply development, the members of the community should be involved in site selection, planning, execution, operation and management. They may also contribute financially in selection, planning, execution, operation and management as this will make the people feel that the water project belongs to them and therefore should be properly protected and managed.

iv. **Use of Worst-first/Extreme needs method in selecting communities for Water Supply Development:** The high-water deficiency zones should be identified and provided with water first before the low water deficiency zones. For the supply development, there should be counterpart funding between the developing agencies and the rural people. For the water distribution, the public standpipes should be located in areas of population concentration and in locations that are central to the people to reduce the water collection distance.

v. **Setting up of Community Water Development Committees:** A community water development committee should be set up in all the villages/communities. This committee should be charged with the mobilization and organization of the people for water supply programmes.

Conclusion

Water scarcity affects one in three people on every continent of the globe. The situation is getting worse as needs for water rise along with population growth, urbanization and increases in household and industrial uses. Almost one fifth of the world's population (about 1.2billion people) lives in areas where the water is physically scarce. One quarter of the global population also live in developing countries that face water shortages due to lack of infrastructure to fetch water from rivers and aquifers.

Water abundance and scarcity could be explained by geology, climatic variability and other factors such as increased demand for water caused by population growth, changes in the economy, development of new technologies, changes in watershed characteristics and water management decisions.

In addition to the typical impacts on water management, climate change introduces an additional element of uncertainty about future water resource management.

Water resources should be heavily managed. The need for integrated water management and pollution control schemes is very important in our present water thirsty world. Implementation of adaptation measures, such as water conservation, use of markets to allocate water, and the application of appropriate management practices will have an important role to play in determining the impacts of climate change on water resources.

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