

Water Scarcity and Water Security: Political and Social Implications



Workshop on Renewable Energy and Water

IEA Working Party on Renewable Energy Technologies

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Outline of Presentation

- The role of water and its security
- The basics of water supply and demand
- Social and political implications of water scarcity
- The linkage between water and energy
- A role for renewable energy
- Middle East case study
- Concluding thoughts

Water Security

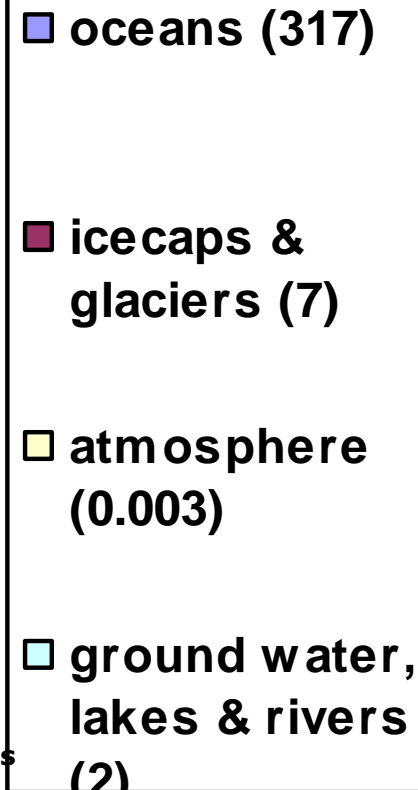
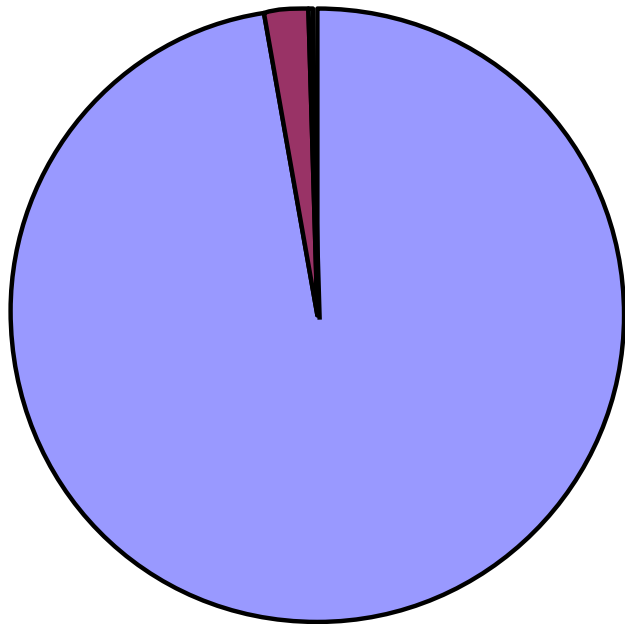


- Water security may be defined as **“the ability to access sufficient quantities of clean water to maintain minimal standards of food and goods production, sanitation and health”**
- Lack of water security is a serious and growing global crisis with **major implications for human health, food production, economic development and poverty reduction, national and regional stability and conflict, and gender equity**
- **Climate change threatens to alter precipitation patterns and exacerbate water supply problems in many parts of the world**

Earth's Water Supply – Key Facts

Global Water Supply

(329 million cubic miles)*



99.7% of all the water on earth is unavailable for human or animal consumption

Of the remaining 0.3%, much is not accessible due to unreachable locations and depths

The vast majority of water used for human and animal consumption, much less than one percent of the total supply, is stored in ground water

*each cubic mile contains more than one trillion gallons

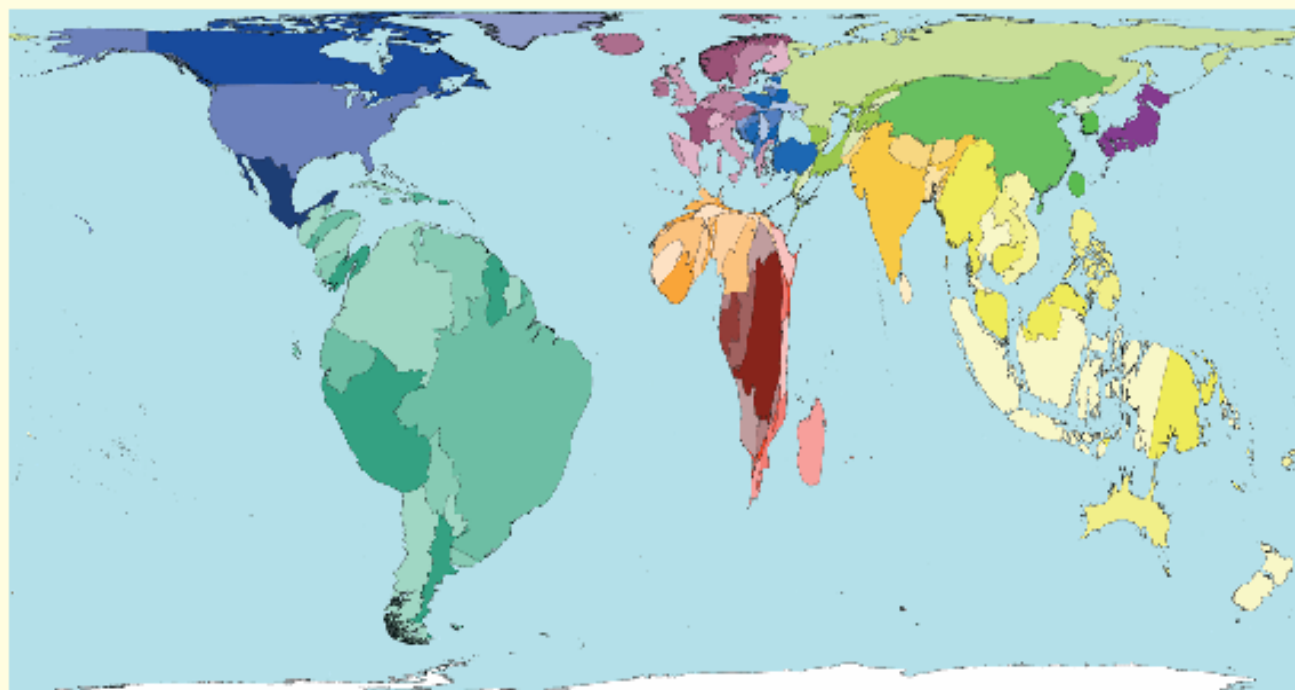
The Growing Demand for Fresh Water

- Population growth and economic development are driving a steadily increasing demand for new clean water supplies
- **World water demand**, approximately **4,200 cubic kilometers in 2000**, has more than tripled over the past half century and is estimated to **be about 30% of the world's total accessible fresh water supply**
- **That fraction may reach 70% by 2025**

The Current Global Situation

- The World Health Organization estimates that, globally, about **one billion people lack access to clean water** supplies, and that more **than two billion lack access to basic sanitation**
- **1,000 m³ is the per capita** annual amount of water deemed necessary to satisfy basic human needs:
 - In 1995 166 million people in 18 countries lived below that level
 - By 2050 clean water availability is projected to fall below that level for 1.7 billion people in 39 countries

Water Resources



Water resources here include only freshwater, because saline (sea) water requires treatment before most uses.

Only 43 600 cubic kilometres of freshwater is available as a resource each year, despite more than twice this amount falling as precipitation (rain and snow). Much is lost through evaporation. Those countries with higher rainfall often have larger water resources. Of all the water available, the regions of South America and Asia Pacific have the most.

People living in Kuwait use sea water that is processed at a desalination plant. As such Kuwait has no area on this map because there are no freshwater resources there.

Territory size shows the proportion of all worldwide freshwater resources found there.



Land area

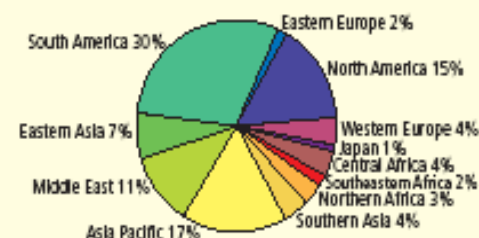
- Technical notes**
- These data are from the United Nations Environment Programme.
 - Only freshwater resources are shown here.
 - *Kuwait had no recorded freshwater resources
 - See website for further information.

MOST AND LEAST WATER RESOURCES

Rank	Territory	Value	Rank	Territory	Value
1	Sao Tome and Principe	227	190	Qatar	0.46
2	Sierra Leone	223	191	Oman	0.32
3	Costa Rica	220	192	Turkmenistan	0.29
4	Liberia	208	193	Niger	0.28
5	Colombia	203	194	Bahamas	0.20
6	Bhutan	202	195	Egypt	0.18
7	Panama	198	196	United Arab Emirates	0.18
8	Taiwan	186	197	Saudi Arabia	0.11
9	Papua New Guinea	177	198	Mauritania	0.04
10	Malaysia	177	199	Libyan Arab Jamahiriya	0.03

centimetres of water per year (cubic centimetres of water volume per square centimetre of land area)*

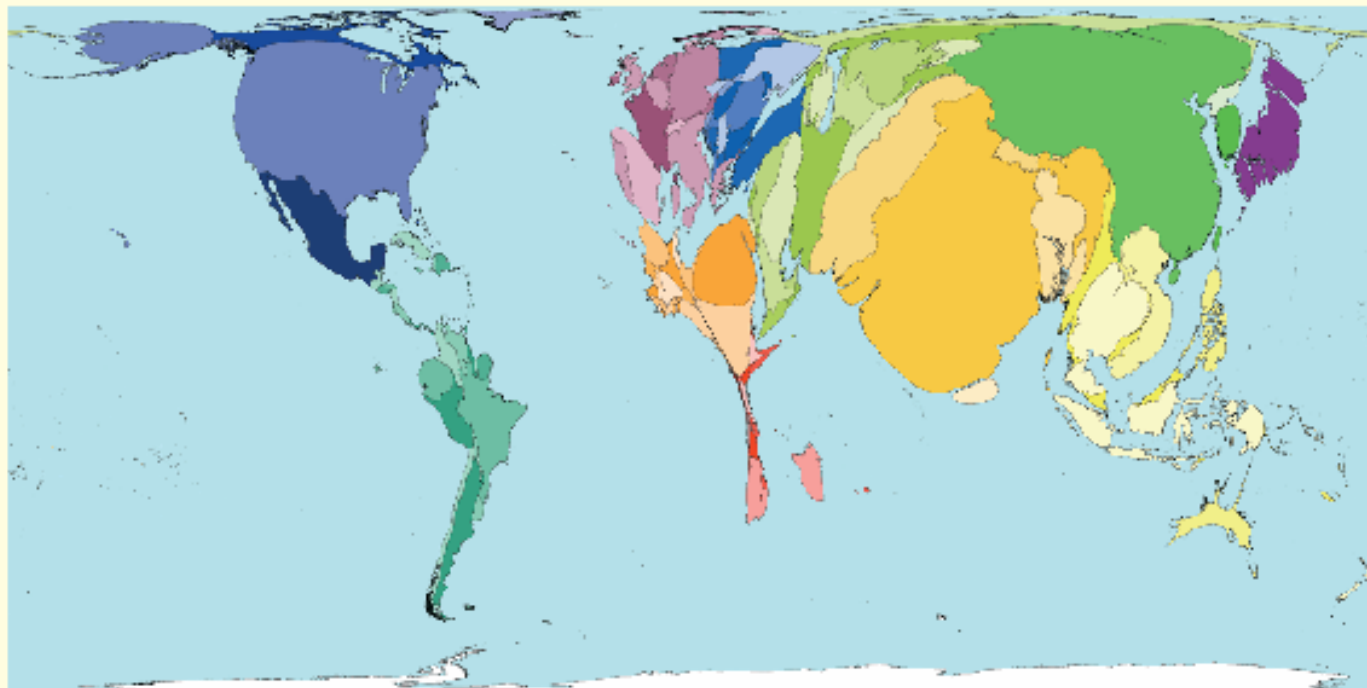
WORLD WATER RESOURCE DISTRIBUTION



“The Amazonian basin, where ten of the twenty largest rivers in the world are to be found ... represents one fifth of the entire fresh water reserves of the planet.”

Brazilian Government's Ministry of External Affairs, 2002

Water Use



Four thousand cubic kilometres of water are used by people each year around the world, for domestic, agricultural and other industrial purposes. This does not include non-consumptive uses such as energy generation, mining, and recreation.

China, India and the United States use the most water. These are also the territories where the most people live. But water use per person is about three times higher in the United States than it is in India and China.

Whilst everybody needs water, people use hugely varying quantities. On average, people living in Central Africa each use only 2% of the water used by each person living in North America.

Territory size shows the proportion of worldwide water use occurring there.



Land area

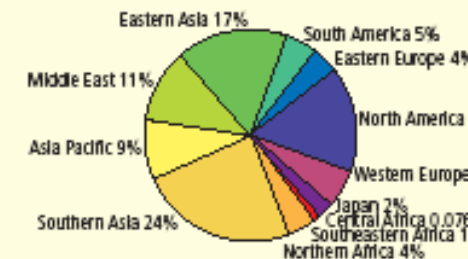
Technical notes
 • Data are from the United Nations Environment Programme.
 • See website for further information.

MOST AND LEAST WATER USAGE

Rank	Territory	Value	Rank	Territory	Value
1	Bangladesh	64	191	Djibouti	0.04
2	Bahrain	44	192	Namibia	0.03
3	Mauritius	31	194	Angola	0.03
4	Belgium	27	193	Mongolia	0.03
5	Japan	24	195	Botswana	0.03
6	Netherlands	24	196	Chad	0.02
7	Pakistan	23	197	Papua New Guinea	0.02
8	Maldives	23	198	Dem Republic Congo	0.02
9	Viet Nam	23	199	Congo	0.01
10	India	22	200	Central African Republic	<0.01

centimetres of water use per year (cubic centimetres of water volume per square centimetre of land area)

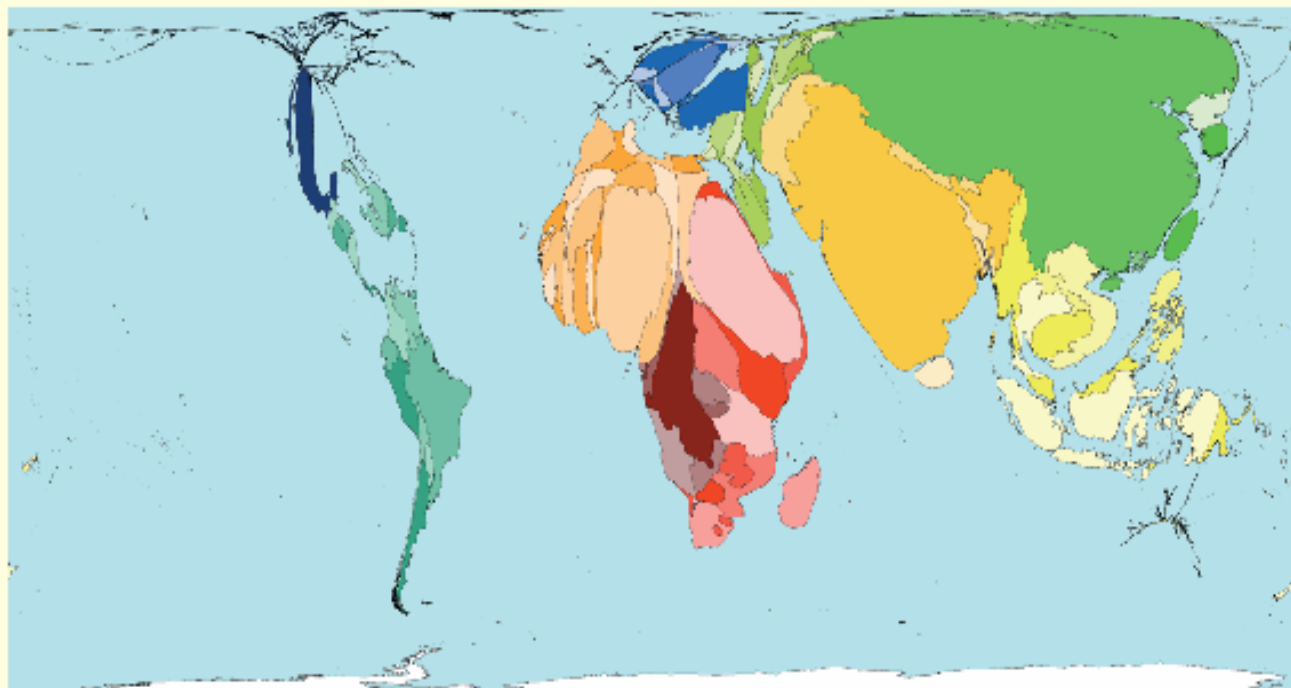
WORLD WATER USE



“... the right to water emanates from and is indispensable for an adequate standard of living as it is one of the most fundamental conditions for survival.”

Céline Dubreuil, 2006

Poor Water



Drinking water is essential to live, but dirty drinking water is also a major cause of disease. Whilst most people living in Western Europe can access safe water, only 50% of people living in Central Africa can do this.

The largest population without access to safe tap water is in China: that is 324 million people, or 25% of the population. In a quarter of all territories more than a quarter of the population is without access to safe water. Worldwide 18% of people have no safe drinking water.

Safer water can be obtained by treating water, collecting it from a spring, or pumping it up from groundwater.

Territory size shows the proportion of all people without reliable access to safe water that live there.



Technical notes

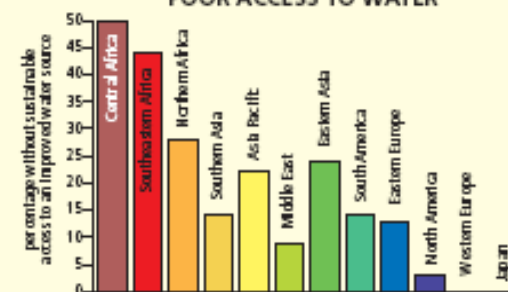
- Data are from the United Nations Development Programme's 2004 Human Development Report.
- *In 40 territories less than 1% of population has not got a reliable source of safe drinking water.
- Poor water is water that is either not safe or is unreliable.
- See website for further information.

LEAST AND GREATER ACCESS TO SAFE DRINKING WATER

Rank	Territory	Value	Rank	Territory	Value
1	Ethiopia	76	151	Bahamas	3
2	Chad	73	151	Albania	3
3	Cambodia	70	153	Greenland	3
4	Mauritania	63	154	Ukraine	2
4	Lao People's Dem Republic	63	154	Saint Lucia	2
6	Angola	62	154	Uruguay	2
7	Oman	61	154	Saint Kitts & Nevis	2
8	Rwanda	59	158	Russian Federation	1
9	Burkina Faso	58	158	Samoa	1
9	Papua New Guinea	58	158	Hungary	1

percentage of population without sustainable access to an improved water source 2000*

POOR ACCESS TO WATER



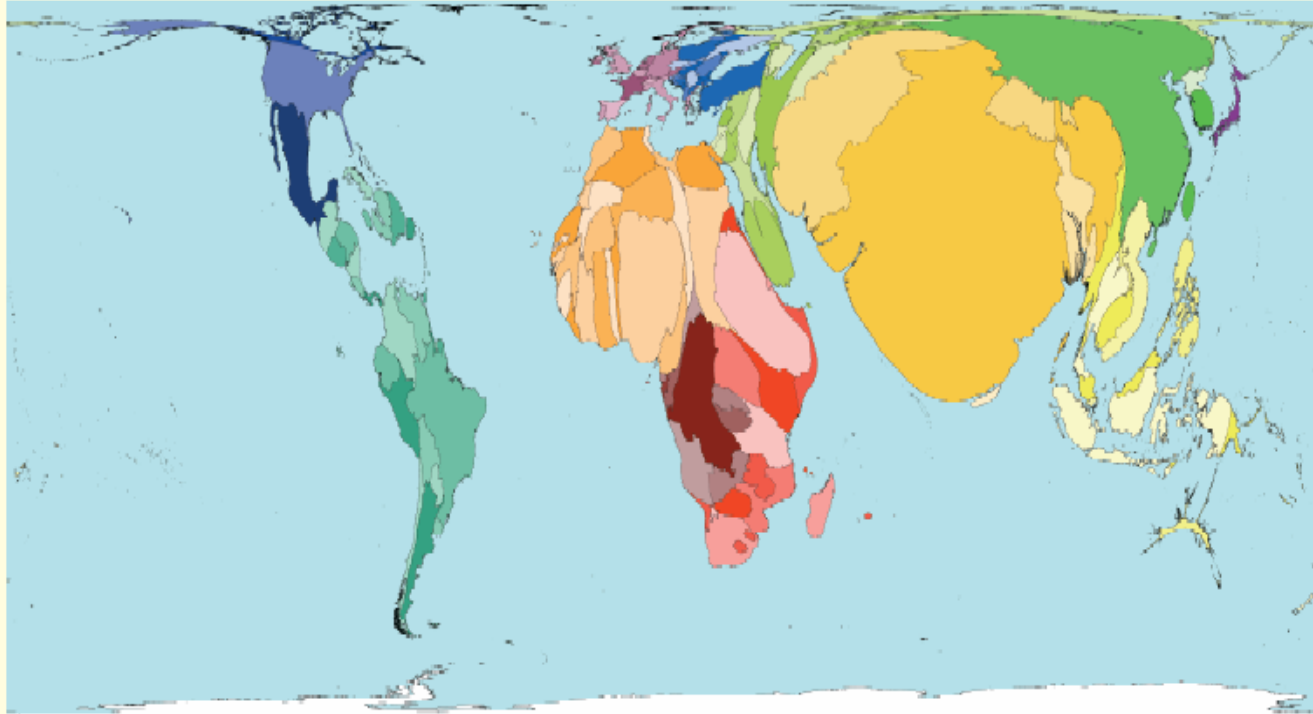
"It is the cause of debilitating diseases for the majority of children. That is how serious a lack of sanitation and clean water is."

Hans Spruijt, 2004

Health Implications of Water Scarcity

- **Water-borne diseases account for roughly 80% of infections in the developing world**
- *Nearly 4 billion cases of diarrhea occur each year*
- *200 million people in 74 countries are infected with the parasitic disease schistosomiasis*
- *Intestinal worms infect about 10% of the population in the developing world*
- *It is estimated that 6 million people are blind from trachoma, and that the population at risk is 500 million*

Childhood Diarrhoea



Diarrhoea is common amongst children. In an average two week period, an estimated 82 million children aged 0-5 years old have diarrhoea. Diarrhoea varies its severity - some children recover quickly, a small proportion but large number die. Access to clean water and rehydration salts can reduce prevalence and minimise the impact.

The highest prevalence of diarrhoea amongst children was recorded in Niger, where 4 in every 10 children had diarrhoea in a typical two week period. Most children in Niger will have many episodes a year causing general chronic debility.

Territory size shows the proportion of worldwide cases of diarrhoea found in children aged 0-4 living there.



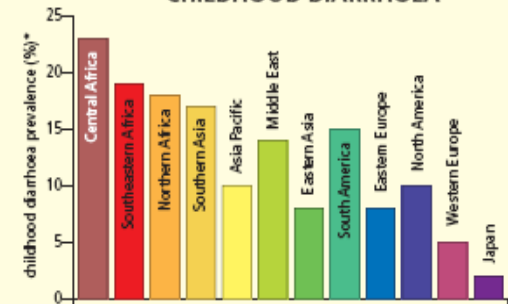
Land area

HIGHEST RATES OF DIARRHOEA IN A TWO WEEK PERIOD

Rank	Territory	Value	Rank	Territory	Value
1	Niger	40	11	Haiti	26
2	Guinea-Bissau	32	12	Sierra Leone	25
3	Chad	31	13	Bolivia	25
4	Togo	31	14	Ethiopia	24
5	Sudan	29	14	Eritrea	24
6	Angola	28	20	Dem Republic Congo	23
7	Nepal	28	21	Azerbaijan	22
7	Yemen	28	22	Gambia	22
9	Central African Republic	27	23	Zambia	21
10	Pakistan	26	24	Tajikistan	21

childhood diarrhea per 100 children 2002*

CHILDHOOD DIARRHOEA



- Technical notes**
- Data are from the World Bank's 2005 World Development Indicators.
 - *Data estimated for Central Africa not in table. Western European and Japanese data are estimates. Data collected from most recent surveys of a 2 week period, 1991-2002.
 - Data counts 0-5 year olds who had diarrhoea in the 2 weeks prior to the survey.
 - See website for further information.

"I now know that how critical it is to wash hands with soap before eating so as to prevent germs from entering my body. This will protect me from infections such as diarrhoea."

Manoj Patel, 2005

Gender Implications of Water Scarcity

- Women head one third of the world's families and often are the family's financial mainstay and principal water provider
- Women are responsible for half of the world's food production, and produce between 60 and 80% of food in developing countries
- **To produce food (and sanitation) they must first “produce” water:**
 - up to 8 hours per day finding, collecting, purifying water
 - if no clean water available, pay exorbitant prices and/or use contaminated water
- Women's water needs often ignored or undervalued by male decision makers, leading to women being among the poorest of the poor in most parts of the world (“feminization of poverty”)

Political Implications of Water Scarcity

- An important feature of the earth's supply of fresh water is its **non-uniform distribution** around the globe
- **Water has been a source of tension wherever water resources are shared by neighboring peoples: 215 “international” rivers and more than 300 water basins shared by 2-3 countries**
- Tensions can lead to instability and conflict in regions on which other nations depend for oil and natural gas:
 - **Middle East:** tensions between Israel and Palestinian Authority, Israel and Syria, Egypt and Sudan, and among Turkey, Syria and Iraq.
 - **Central Asia:** significant national water disparities may lead to conflicts
- Climate change will exacerbate water supply problems, possibly leading to migrations within countries and across borders

Responding to the Growing Crisis

- Only recently has water scarcity attracted broad world attention:
 - World Water Forums in 1997, 2000, 2003, 2006, 2009 (Turkey)
 - UN declared 2003 the International Year of Fresh Water and 2005-2015 the UN Decade of Water
 - UN Millenium Summit (2000) and World Summit on Sustainable Development (2002) identified water (and energy) as critical to eradication of poverty and achieving sustainable development
- Two Millenium Development Goals were adopted in 2000 related to water: **to reduce by half, by 2015, the proportion of people without access to safe drinking water and basic sanitation**
 - reaching the goals is problematic
 - even if reached, 600 million will still lack access to clean water and 1.5 billion to adequate sanitation

How Are Water and Energy Related?

- **Central to achieving water security is having the energy to**
 - extract water from underground aquifers
 - transport water through canals and pipes
 - manage and treat impaired water for reuse, and
 - desalinate brackish and sea water to provide new fresh water supplies
- **Water is critical to many forms of energy production**
 - hydropower
 - cooling of thermal power plants
 - fossil fuel production and processing
 - biomass production
 - hydrogen economy
- **Water and energy issues are inextricably linked**

Other Linkages



- Energy production and use can lead to **contamination** of underground and surface water supplies
- **Energy and water policy can be expressed in identical terms:** the first priority must be the **wise use of available resources**; then focus on developing and **harvesting new resources** that meet sustainability and environmental requirements
- **Globally, neither energy nor water are in short supply.** What is in short supply is energy and clean water that people can afford to buy.

A Need for Desalination

- Extensive use of desalination will be required to meet needs of growing world population.

energy costs are the principal barrier

- *15,000 desalination units today, producing 40 million cubic meters of fresh water daily; more than 50% of capacity in Middle East*
- *30 plants in Saudi Arabia meet 70% of drinking water demand and several new plants under construction*

two principal technologies:

reverse osmosis (44%; 5 kWh /m³);

multi-stage flash distillation (40%; 25 kWh/m³)

- *costs from large-scale plants typically in the range 60-90 US cents/m³*

- Water delivery currently uses 6% of world energy consumption

A Role for Renewable Energy

- Where is the energy to come from to achieve water security ?
- Today, diesel generators, but not cheap or environmentally benign
- **Renewable energy can play a role** in meeting this challenge, both in developing and developed countries
 - solar- or wind-powered **water pumping** can raise water from depth and move it to where it is needed
 - Solar- or wind-powered **desalination of plentiful brackish water** via reverse osmosis can provide significant new sources of water in areas that have few if any other potable sources of water – e.g., Middle East
 - Solar- or wind-powered ultraviolet systems can be used in remote locations to **decontaminate impaired water** by disrupting DNA of viruses and bacteria

Other Possibilities



- **Concentrating solar thermal power (CSP) systems:**
 - heat water to drive steam turbines
 - Can be jointly operated as electricity and potable water providers
- **Ocean energy systems** (wave, tidal, ocean current, OTEC);
 - generated electricity can be used to desalinate seawater
 - wave energy systems can be designed to desalinate by forcing water through membranes
 - open cycle Ocean Thermal Energy Conversion systems produce potable water as byproduct

The Middle East Water Situation (Table 1)

Population (millions)*

	<u>2000</u>	<u>2020</u>	<u>Rate</u> (%)
○ Jordan	4.9	9.2	4.4
○ PA	3.2	5.3	3.3
○ Israel	<u>6.5</u>	<u>9.4</u>	<u>2.2</u>
	14.6	23.9	3.2

* "Middle East Regional Study on Water Supply and Demand Development," German Agency for Technical Cooperation, 1998

The Middle East Water Situation (Table 2)

Projected **Water Demand** – Base Case (10⁶ m³/year)

	<u>1994</u>	<u>2040</u>	<u>Rate</u> (%)
● Jordan	909	246	3.7
● West Bank	127	720	10.2
● Gaza Strip	108	380	5.5
● Israel	<u>1904</u>	<u>3766</u>	<u>2.1</u>
	3048	7333	3.1

The Middle East Water Situation (Table 3)

Projected Fresh Water Shortages (10⁶ m³/year)*

	<u>Base</u>	<u>Low</u>	<u>High</u>
● <u>2010</u>	720	200	1210
● <u>2040</u>	2280	870	3480

* Zero water shortage is equivalent to the 1994 water supply of 3x10⁹ m³/year

Middle East Case Study

- Addressing water security concerns in the Middle East is central to peace between the Palestinians and the Israelis
- Nabil Al Sharif (former Minister of the Palestinian Water Authority):
 - “.....there will be no real peace if there is no water. If there is no water, I don't think any agreement of peace will live more than two or three years.”
- **Two important resources present in large quantity in the Middle East are brackish water and solar radiation**
- Widespread use of **solar energy to power desalination** of brackish water can help **address water security** issues and **contribute to the peace process.**

Origins of the Desalination Project

- Many arid and desert-like regions with large populations (e.g., MENA) suffer from scarcity of fresh water
- Often the only water resource is brackish water with salinity levels in the range 3,000 - 8,000 ppm
- Many small communities without electricity and fresh water exist in Jordan and on the West Bank
- It was recognized that if energy were available to bring brackish water to the surface and reduce salinity levels to World Health Organization standards for potable water, one could
 - improve health and sanitation conditions
 - help generate sustainable economic development

The Desalination Project



- Initiated in 1997 by U.S. DOE and U.S. AID with five objectives:
 - foster cooperation and confidence building among the regional partners
 - demonstrate in remote villages the feasibility of operating small, solar powered desalination units for brackish water
 - increase local institutional and individual capacity in areas related to renewable energy and desalination technologies
 - stimulate a joint design effort by the regional partners for desalination units suitable for use in remote villages
 - stimulate regional manufacture of the jointly designed desalination units.

The Installations



- The project involved **three project locations** – two in Jordan and one in the West Bank village of Marj Na'aja near Jericho
- The first desalination unit was located at a site selected by the Jordanian Ministry of Water and Irrigation - Qatar, a small village 35 kilometers north of Aqaba
 - 35 households, 250 residents plus some nomadic Bedouins
 - annual average income: \$84-169 (livestock breeding)
 - no fresh water supply (trucked in weekly from Aqaba)
 - two wells drilled into a brackish water reservoir (depth: 50 meters; salinity: 3,865 ppm)
 - Annual average solar insolation: 6 kilowatts/m²/day

The Village of Qatar



Figure 1

Qatar Desalination System



- Reverse Osmosis Water Purification Unit
- **Brackish water (3,400 ppm)** pumped by submersible pump to storage tank on surface, which directs feed water to desal unit
- Water leaves desal unit in two branches:
 - **potable water (600 ppm)** that is stored in special tank, and
 - brine (elevated salinity) that is directed to lined evaporative pond
- Unit operates **7 hours/day and produces 2.75 m³/hour**
- Unit now grid-powered - grid has been extended to Qatar

Brine Disposal Pond



The Second Installation

- Located at industrial park on outskirts of Aqaba
- Delta-15 RO desalination unit (Crane Environmental)
 - 15 gallons per minute of fresh water from brackish water with total dissolved solids of 4,000 ppm
 - PV system: 16.8 kWp



The Third Installation

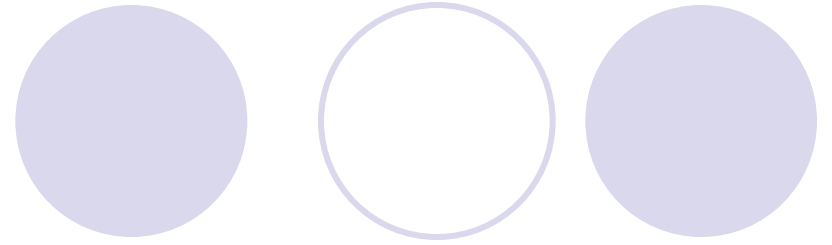
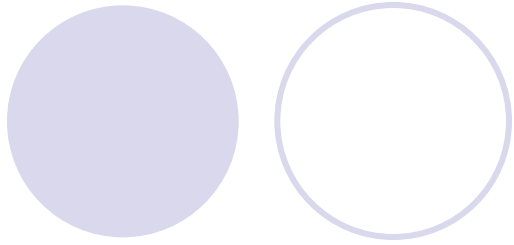


- Site selected by Palestinian Water Authority (PWA):
 - school in village of Na'aja
 - two brackish wells will feed into single feed water reservoir
 - unit is smaller version of Delta-15 (10,000 gallons/day)
- Political and funding issues have delayed installation:
 - unit tested and run through startup operations at Technion
 - onsite training provided to PWA engineers & technicians

Concluding Thoughts



- Water scarcity is already serious in many locations and growing more so each year
- Global climate change will exacerbate these problems
- There are major social and political implications of water scarcity
- Water and energy security issues cannot be separated
- **Renewable energy technologies offer an attractive option for providing the energy needed to alleviate water security problems**
- Strong national efforts and international cooperation are needed to address this growing crisis



**Thanks for your attention
for further info**

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The Rime of the Ancient Mariner

- In 1797 Samuel Taylor Coleridge wrote the following words:

**“And all the boards did shrink; Water, water every where,
Ne any drop to drink”**

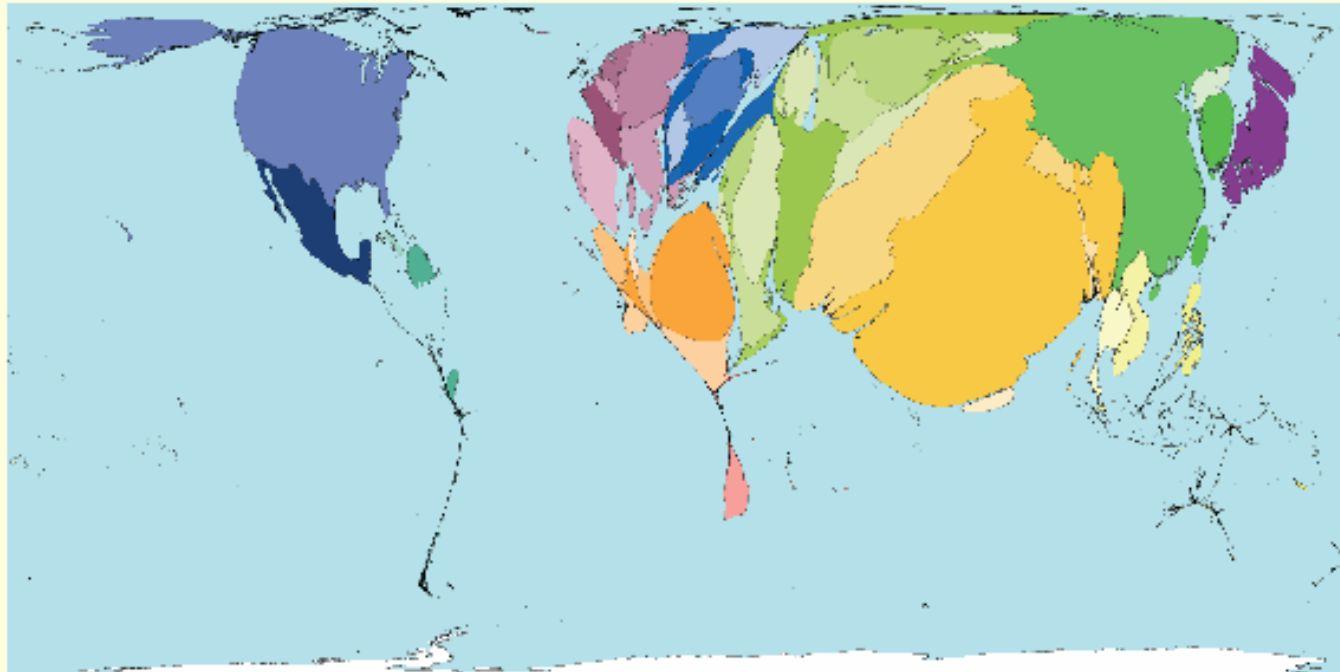
- Two hundred and twelve years later these words continue to have great meaning in a water-rich world where a billion people lack access to clean drinking water

The Role of Water

A decorative graphic at the top of the slide consists of six circles. The first circle on the left is solid light purple. The second circle is a light purple outline. The third circle is solid light purple. The fourth circle is a light purple outline. The fifth circle is solid light purple. The sixth circle is a light purple outline.

- Water has always been mankind's most precious resource – **there are no substitutes**
- The struggle to control water resources has shaped human political and economic history
- “Water is fundamental to life and health. The human right to water is indispensable for leading a healthy life in human dignity. **It is a prerequisite to the realization of all other human rights.**” (UN, 2002)

Water Depletion



This map shows those territories that use much of their internal water resources, measured with a threshold of people using more than 10% of renewable water resources. Each territory is resized based on the volume of water used beyond 10%.

75 of the 200 territories used less than 10% of their renewable internal freshwater resources. 51 territories used between 10% and 100% of water resources, 15 territories used 100% or more. 59 territories were missing data.

Egypt uses 33 times its internal water resources - the River Nile supplies Egypt with rainwater from elsewhere. Water supplies vary: 4 territories use more per person than Egypt but under 5% of their total internal resources.

Territory size shows the proportion of all water used that is more than 10% of the renewable internal freshwater resources of that territory.



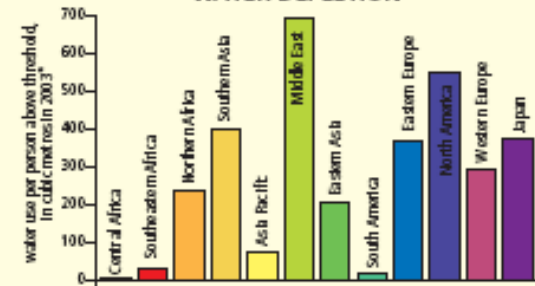
- Technical notes**
- Data are sourced from the World Bank's 2005 World Development Indicators.
 - Middle Eastern territories with rates estimated from the regional average not included in table.
 - An arbitrary threshold of 10% of internal renewable water resources is used to allow for greater use where water is abundant.
 - See website for further information.

HIGH WATER DEPLETION

Rank	Territory	Value	Rank	Territory	Value
1	Turkmenistan	4938	11	Afghanistan	887
2	Uzbekistan	2198	12	Tajikistan	852
3	Azerbaijan	1889	13	Serbia & Montenegro	835
4	Kazakhstan	1694	14	Islamic Republic of Iran	833
5	Iraq	1599	15	Libyan Arab Jamahiriya	815
6	Bulgaria	1470	16	Dominican Republic	733
7	Kyrgyzstan	1082	17	Saudi Arabia	715
8	Pakistan	1003	18	Macedonia FYR	700
9	Romania	975	23	Republic of Moldova	674
10	Egypt	933	24	United States	674

cubic metres of water used above threshold, per person per year, 2003*

WATER DEPLETION



“The moment one starts using freshwater beyond the rate at which it can be replenished, the hydrological cycle is endangered.”

Dinyar Godrej, 2003