Intro to Water, Sanitation, Hygiene (WASH)

D-Lab

Development through Discovery, Design and Dissemination

Water | Sanitation | Hygiene | Environment

Water Supply (Quantity), Water Treatment (Quality)

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Week 2 – D-Lab: WASH

September 11, 2019

Outline – Intro to WASH

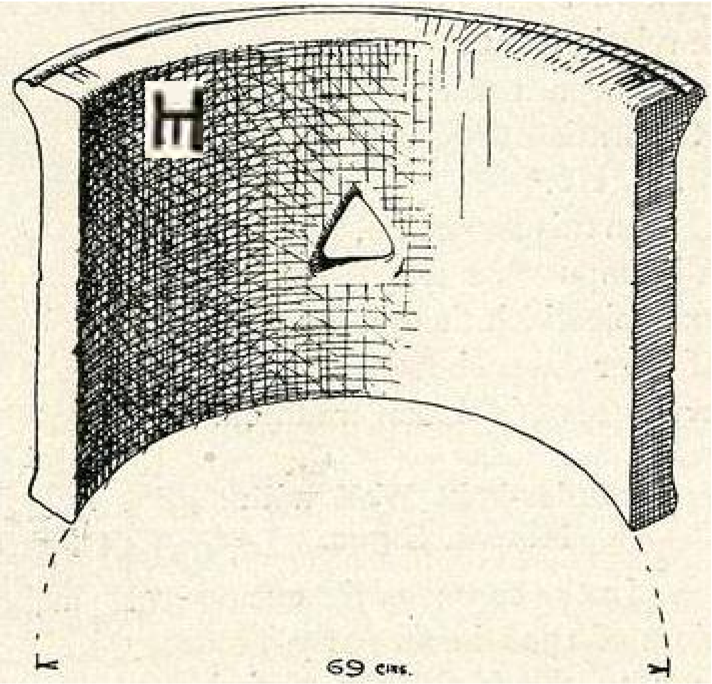
- Global Water Literacy
- WASH Introduction
- Sanitary Engineering from 19th c to 21c MIT
- Millennium Dev Goals (MDGs) and Sustainable Dev Goals (SDGs)
- Annex 1: Examples of Unimproved and Improved Water Supplies (in pictures!)

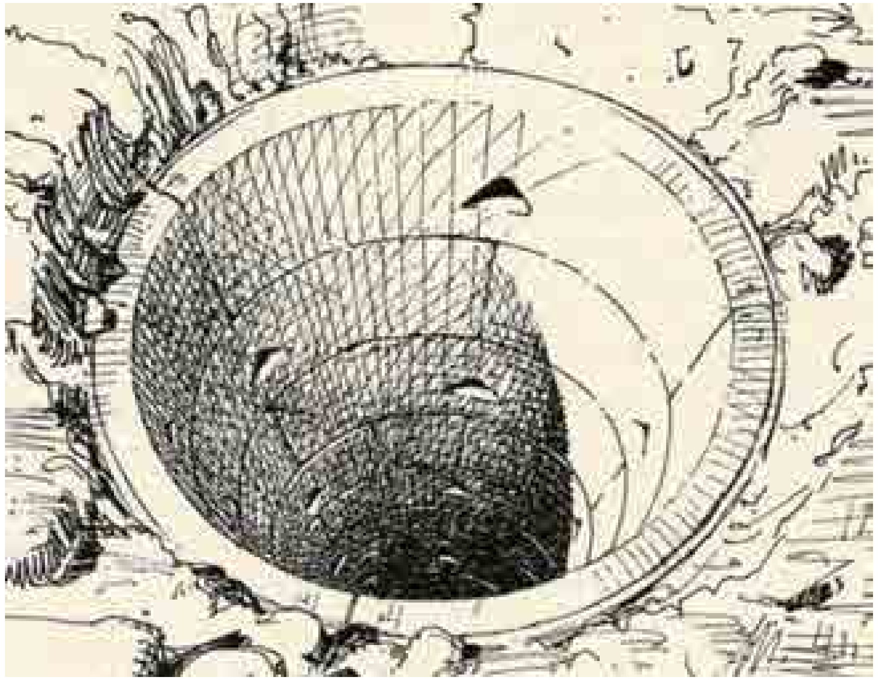
Ostrich Eggs

- Traditional cultures, such as the Bushman of southern Africa, live in close proximity to their water sources and access surface water via simple collection and storage vessels

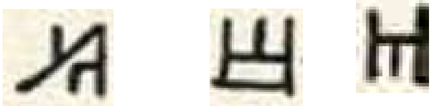
- Are used for water collection, transport and storage in desert areas by Bushman... for at least the last 10,000 years!

Groundwater from Wells in Minoan Civilization, Crete, 4100-3400 BP





- In Minoan civilization, well water was available to most villagers potentially suggesting an equalitarian society
- Depth of wells ranged 13 - 23 m
- Minoans sited wells in the Kouskouras limestone formation indicating awareness of the best geological sites
- They used terracotta cylinders to support well walls,
- Each successive cylinder was identified by “Minoan A” signs



17th & 18th C. New England also relied on groundwater from wells. This was the most common early American source of water

Water Well & Pump,

Old Sturbridge Village

Wells were either public or on private premises

19th c. Water & Technology at WaterWorks Museum

Three original coal-powered, steam-driven water pumps are monuments to 19th century technology and innovation. These pumps, named Leavitt, Worthington, and Allis, which stand in the Great Engines Hall reach more than 3 stories tall. Their perfectly engineered parts pumped millions of gallons of freshwater each day into the City of Boston, the population of which had increased 8-times during the 19th century largely through rural-to-urban migrations and immigration

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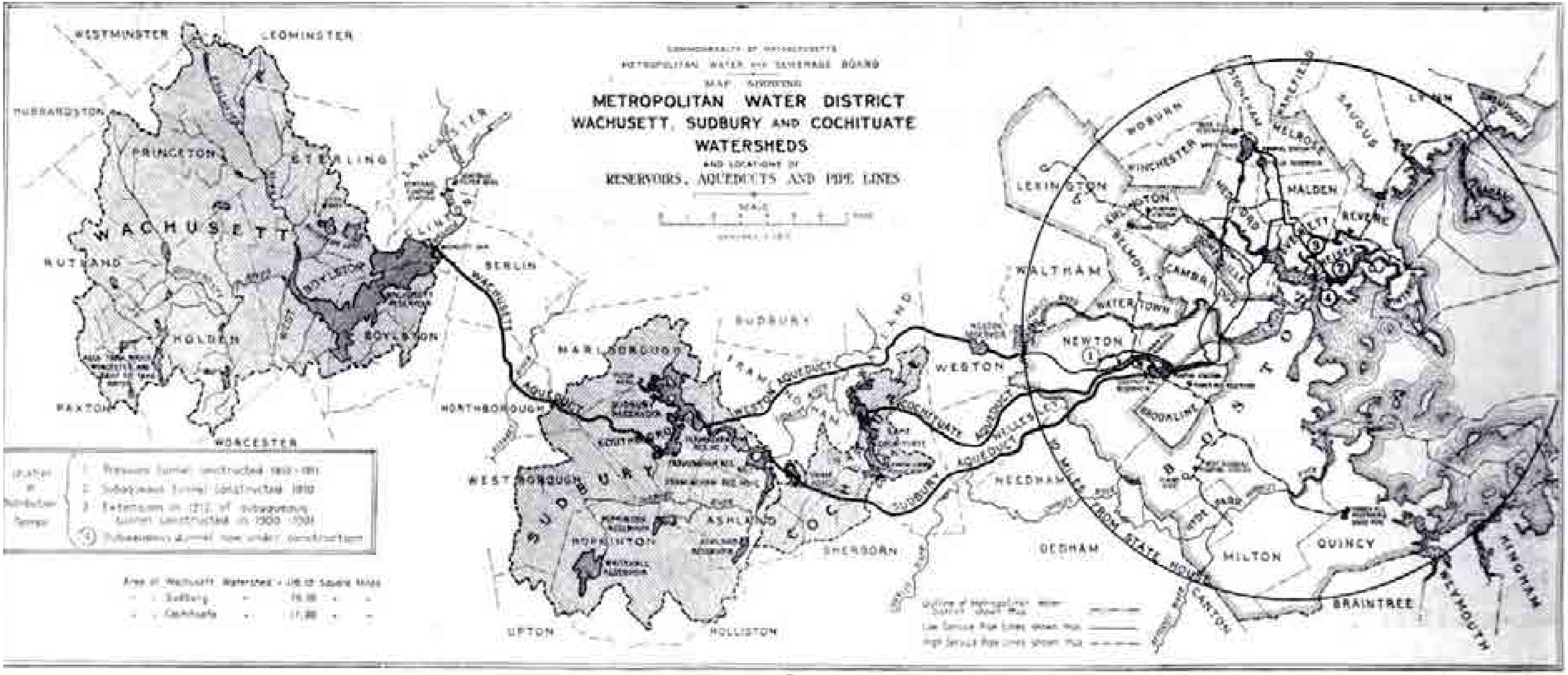
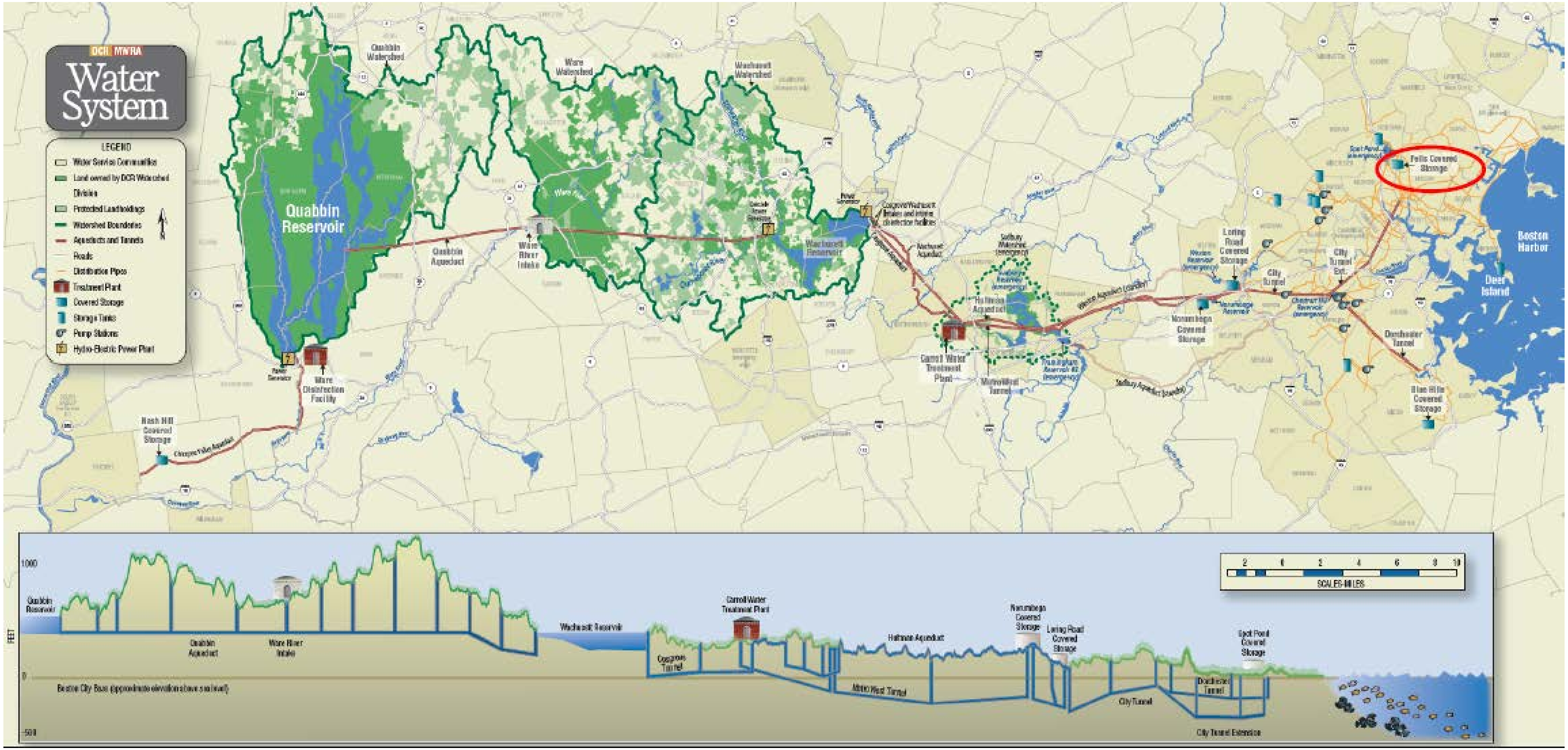
Boston MA Metropolitan Water District Map, 1910



Map of the Massachusetts Water Resources Authority Water System (2018) from Quabbin & Wachusset Reservoirs to John Carroll Treatmt Plant to Boston

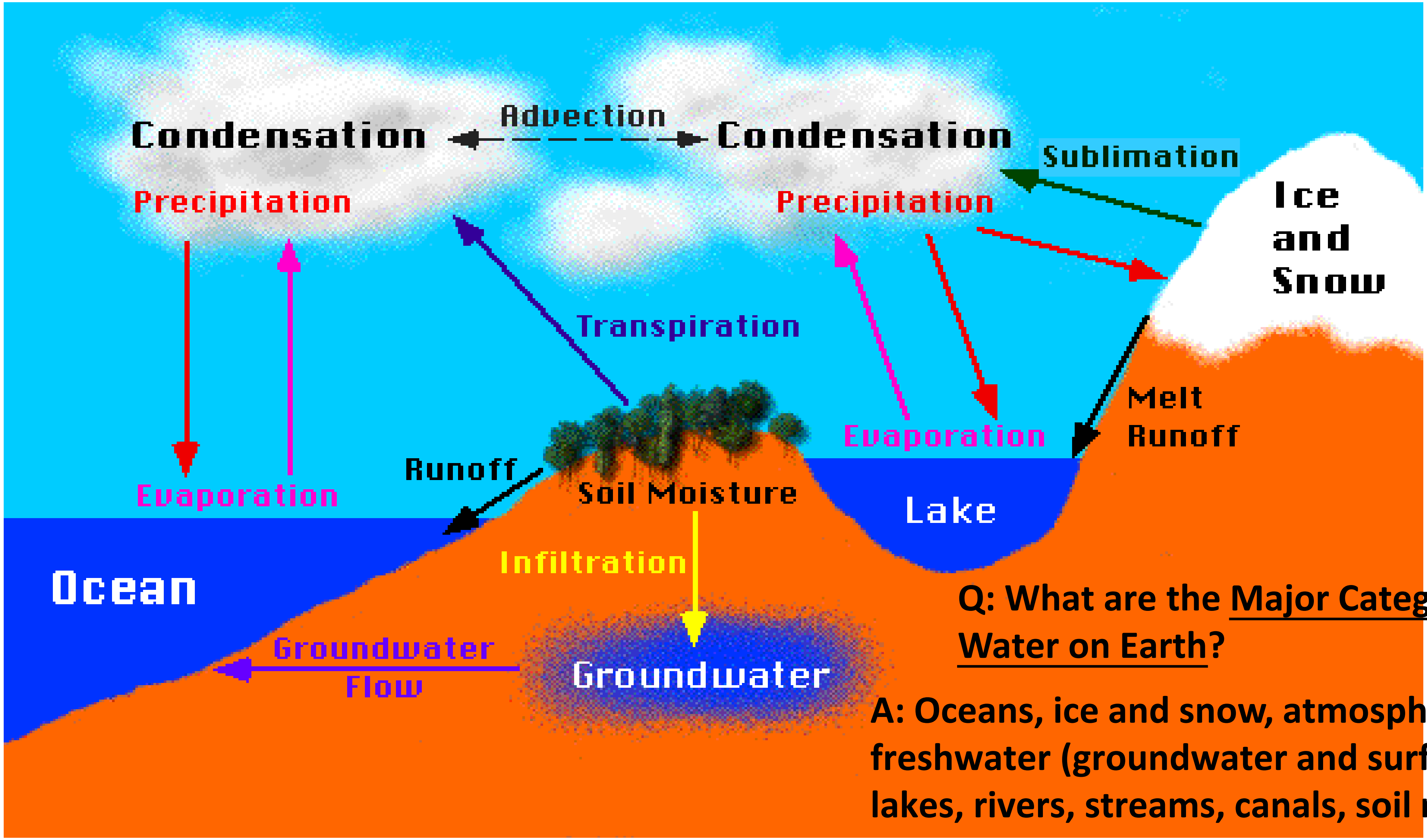


Global Water Literacy: some basic facts about water on earth!

Some topics in this lecture are covered in Ch. 9 reading from Field Guide to Environmental Engineering for Development Workers.

- What are the major sources of water supply?
- How much water is on earth?
- What numbers are widely accepted limits defining water stress & water scarcity?
- What are some of the key dimensions of water stress & scarcity?
- What percentage of water goes to agriculture, industry and domestic sectors?
- What is the status of water and sanitation as human rights?

Water on Earth – the Hydrologic Cycle

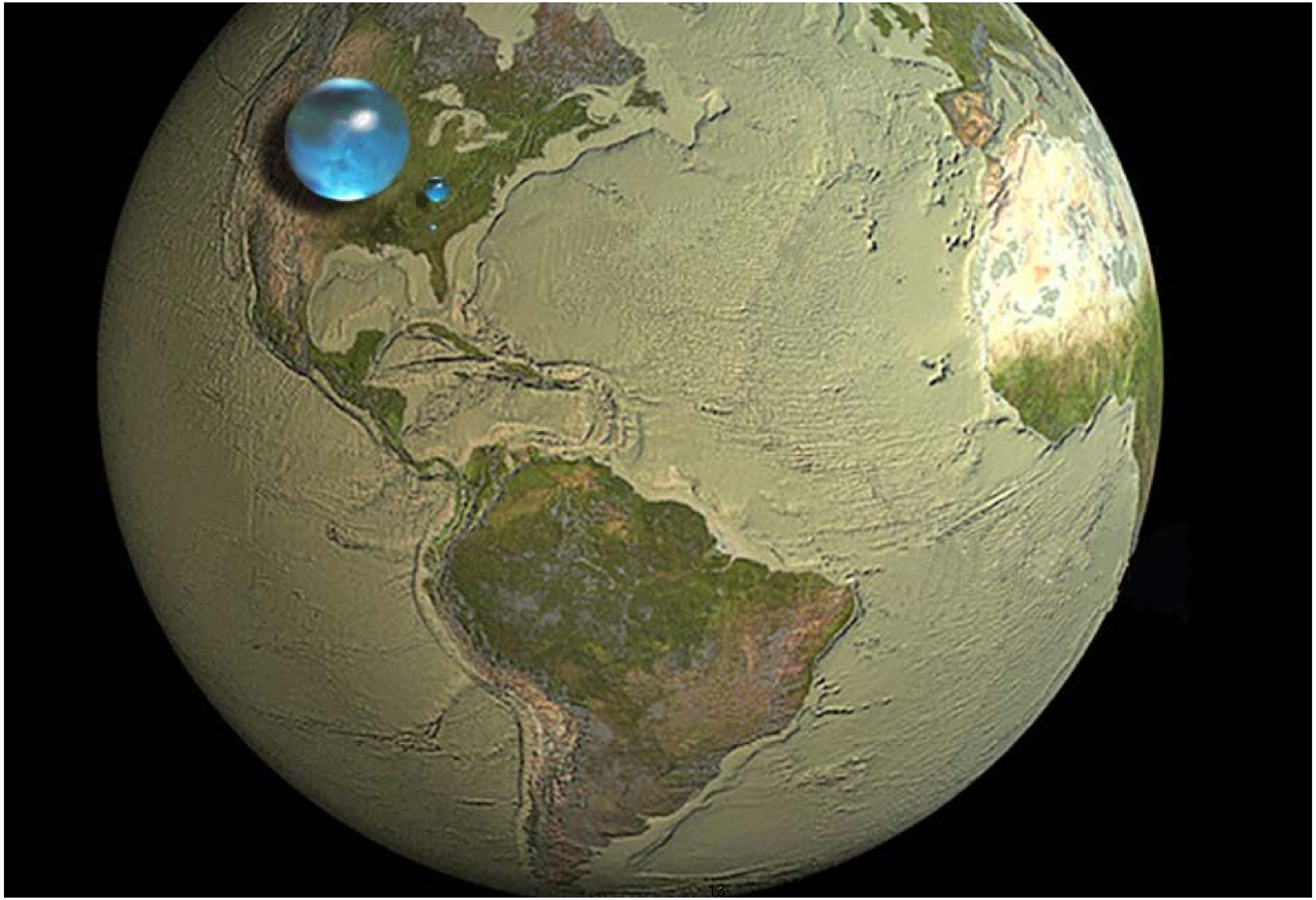


Q: What are the Major Categories of Water on Earth?

A: Oceans, ice and snow, atmospheric water, freshwater (groundwater and surface water = lakes, rivers, streams, canals, soil moisture)

How much water is on earth?

Big sphere= all water on earth (1.4 B km^3). Medium sphere = freshwater on earth (11 M km^3). . Small sphere = surface water on earth (93,000 km^3).



This image is in the public domain.

Big Sphere – All Water on Earth

- Includes all the water in the oceans, ice caps, lakes, and rivers, as well as groundwater, atmospheric water, and even the water in all living things – plant and animals!
- Diameter of 860 miles (the distance from Salt Lake City, Utah, to Topeka, Kansas).
- Volume of 332,500,000 cubic miles (mi^3) (1,386,000,000 cubic kilometers (km^3).

Medium Sphere – Fresh Water

- All the world's fresh water (groundwater, lakes, wetlands, and rivers).
- 99 percent is groundwater (much of which is not accessible to humans).
- Diameter of this sphere is about 169.5 miles (272.8 kilometers).
- Volume 2,551,100 mi^3 (10,633,450 km^3),

Small Sphere – Surface Waters in Lakes and Rivers

- All surface waters (e.g. lakes and rivers, ponds and wetlands) on the planet.
- Most of the water people and living things need comes from surface water sources.
- Diameter of this sphere is 34.9 miles (56.2 kilometers). Note: Lake Michigan looks much bigger than this sphere, but you have to imagine this sphere as almost 35 miles high—whereas the average depth of Lake Michigan is less than 300 feet (91 meters) (0.06 mi)
- The volume of this sphere is about 22,339 mi^3 (93,113 km^3).

What are the 4 main sources of humanity’s water supply?

Major Sources of Water

- Rainwater
- Surface Water
- Groundwater
- Greywater

Graywater Definition:

- All wastewater generated in homes or workplaces without fecal contamination, i.e. NOT from toilets!
- Sources of graywater include sinks, dishwashers, showers, baths, washing machines, yard water.

Minor Sources of Water

- Sea water / saline water
- Reused wastewater
- Dew
- Fog

How much fresh water is on earth?

World's Total Freshwater

Location	% of World's Freshwater
Glaciers, Ice, Permanent Snow	68.7%
Groundwater	30.1%
Sub-Total	**98.8%**
Lakes	0.26%
Soil Moisture	0.05%
Atmosphere	0.04%
Marshes / Wetlands	0.03%
Rivers	0.006%
Biological water	0.003%
Sub-Total	**0.389%**

(UNESCO-WWAP, 2003. Table 9-1 cited in Mihelcic J. et al. "Field Guide to Environmental Engineering for Development Workers, ASCE Press, 2009)

Is water a renewable or non-renewable resource?

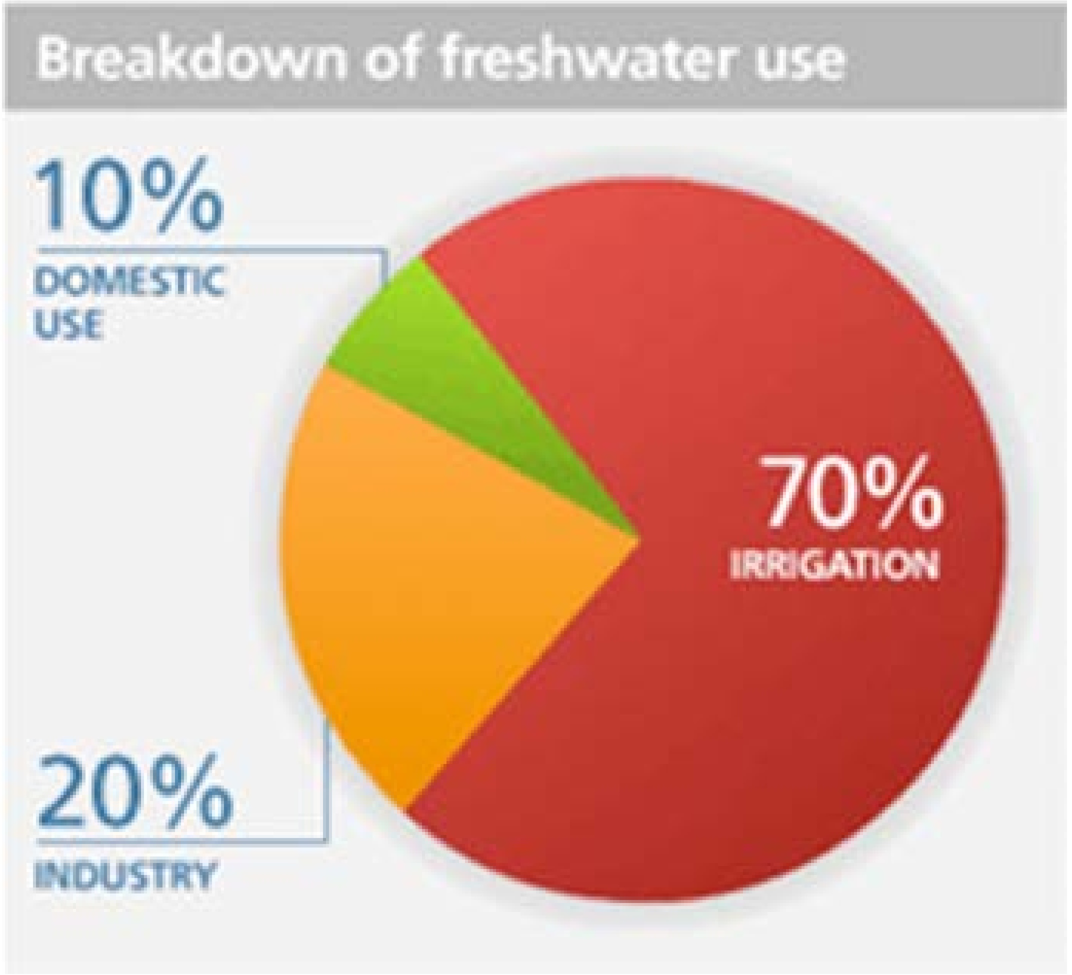
A: Renewable, but finite!

Average Renewal Time for Various Water Resources

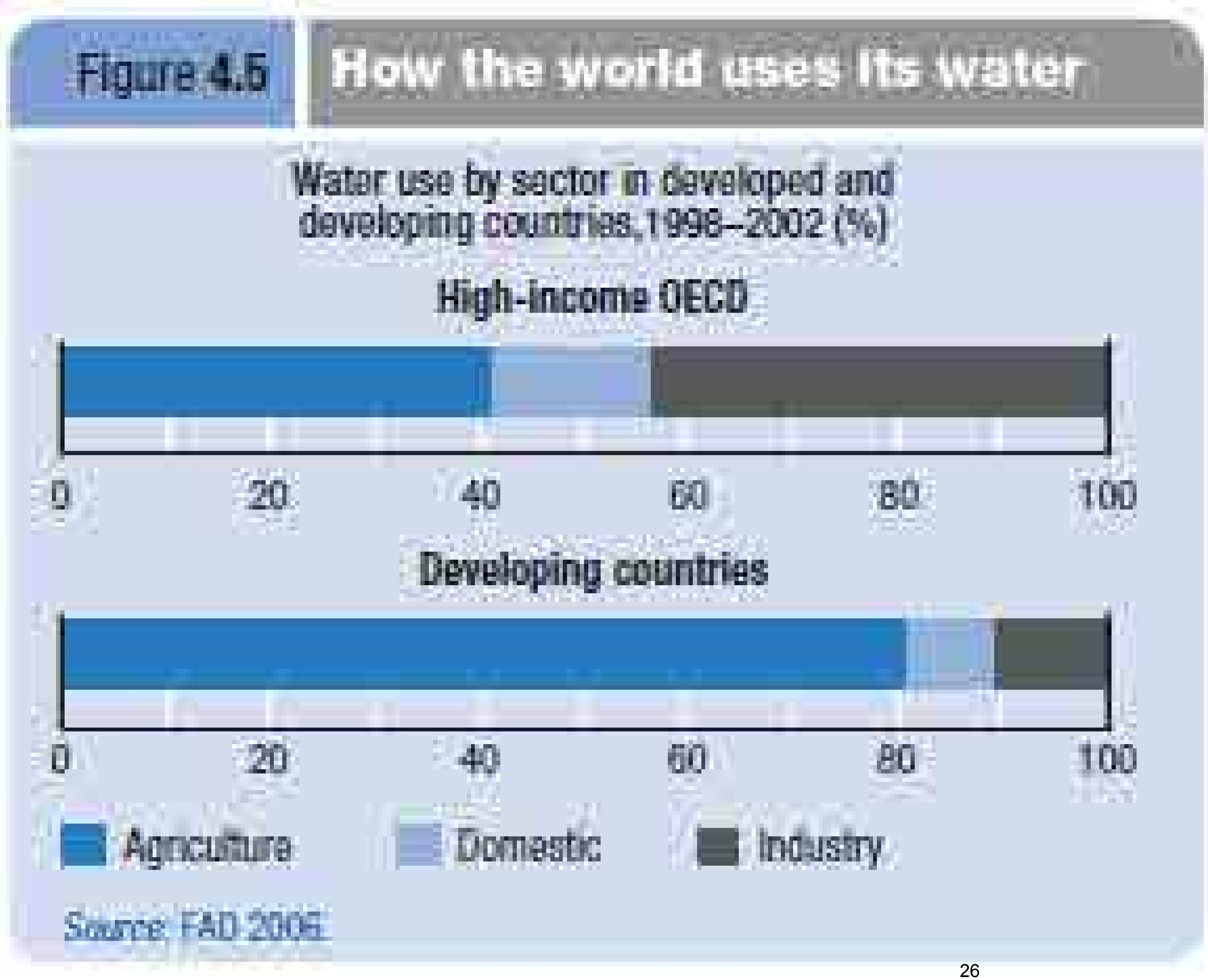
Atmospheric Water	8 days
Rivers	16 days
Wetlands	5 years
Lakes	17 years
Groundwater	1,400 years

(Clarke, R. 1993)

Q: What percentage of global water goes to agriculture, industry and domestic sectors?



Water Use by Sector
in High vs. Low Income Countries



UNDP. 2006. Human Dev. Report. Ch. 4 Water Scarcity, Risk, Vulnerability

Domestic Water Quantity & Service Level

Service level	**Access measure**	*Needs met*	**Level of health concern**
No access (quantity collected often below 5 l/c/d)	More than 1000m or 30 minutes total collection time	Consumption – cannot be assured Hygiene – not possible (unless practised at source)	Very high
Basic access (average quantity unlikely to exceed 20 l/c/d)	Between 100 and 1000m or 5 to 30 minutes total collection time	Consumption – should be assured Hygiene – handwashing and basic food hygiene possible; laundry/ bathing difficult to assure unless carried out at source	High
Intermediate access (average quantity about 50 l/c/d)	Water delivered through one tap on-plot (or within 100m or 5 minutes total collection time	Consumption – assured Hygiene – all basic personal and food hygiene assured; laundry and bathing should also be assured	Low
Optimal access (average quantity 100 l/c/d and above)	Water supplied through multiple taps continuously	Consumption – all needs met Hygiene – all needs should be met	Very low

(Howard & Bartram, 2003)

What are the definitions of water stress & water scarcity?

Water Stress & Scarcity* - Definition

	Units (m3/person/year)
Water Stress	< 1,700 m3/person/year
Water Scarcity	< 1,000 m3/person/year
Absolute Scarcity	< 500 m3/person/year

* Scarcity defined as “insufficient to satisfy normal human requirements.”

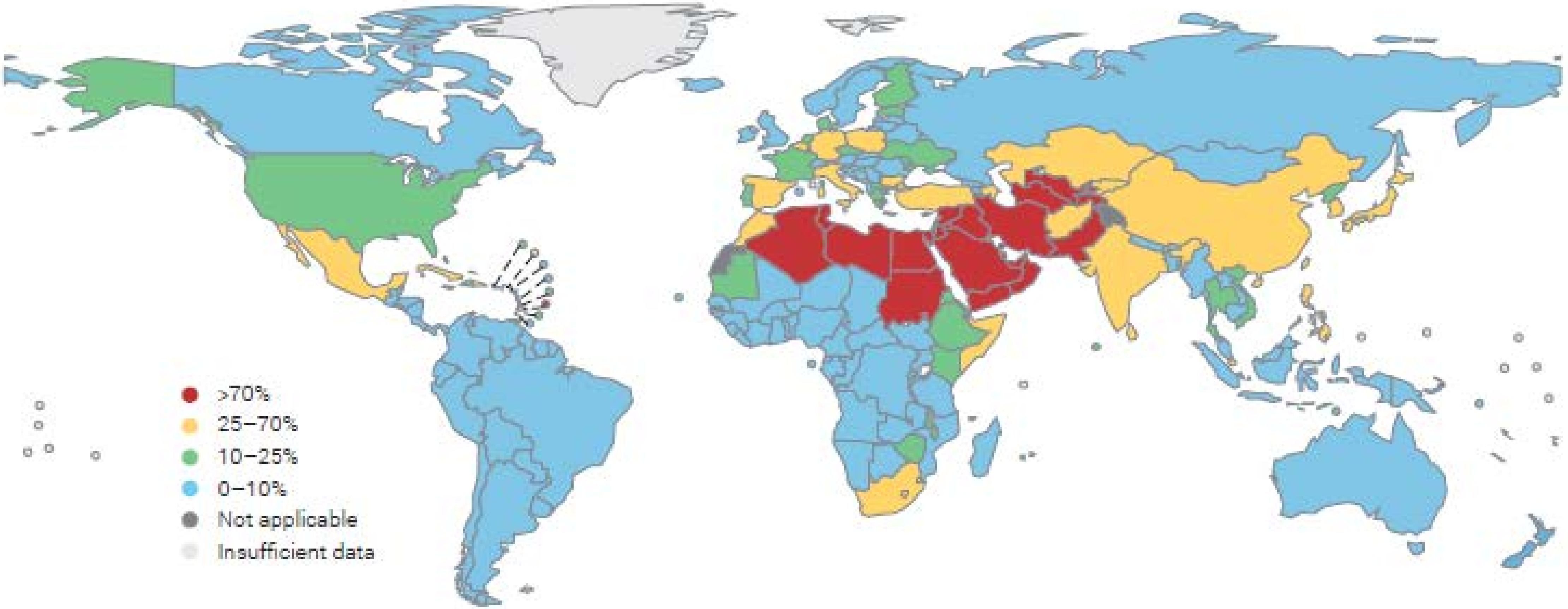
What are some of the different aspects of water stress & scarcity?

Different Aspects of Water Scarcity

- Physical water scarcity is where there is not enough water to meet all demands, including for ecosystem functions. Arid regions frequently suffer from physical water scarcity or it occurs where water resources are over-committed, such as with excess irrigation, as in the American West, or industrial development, as in China. Symptoms of physical water scarcity include environmental degradation and declining groundwater.

- Economic water scarcity, is due to a lack of investment in water or insufficient human capacity to satisfy the demand for water. Symptoms of economic water scarcity include a lack of infrastructure, with people often having to fetch water from rivers for domestic or agricultural uses. Large parts of Africa suffer from economic water scarcity.

Physical Water Stress

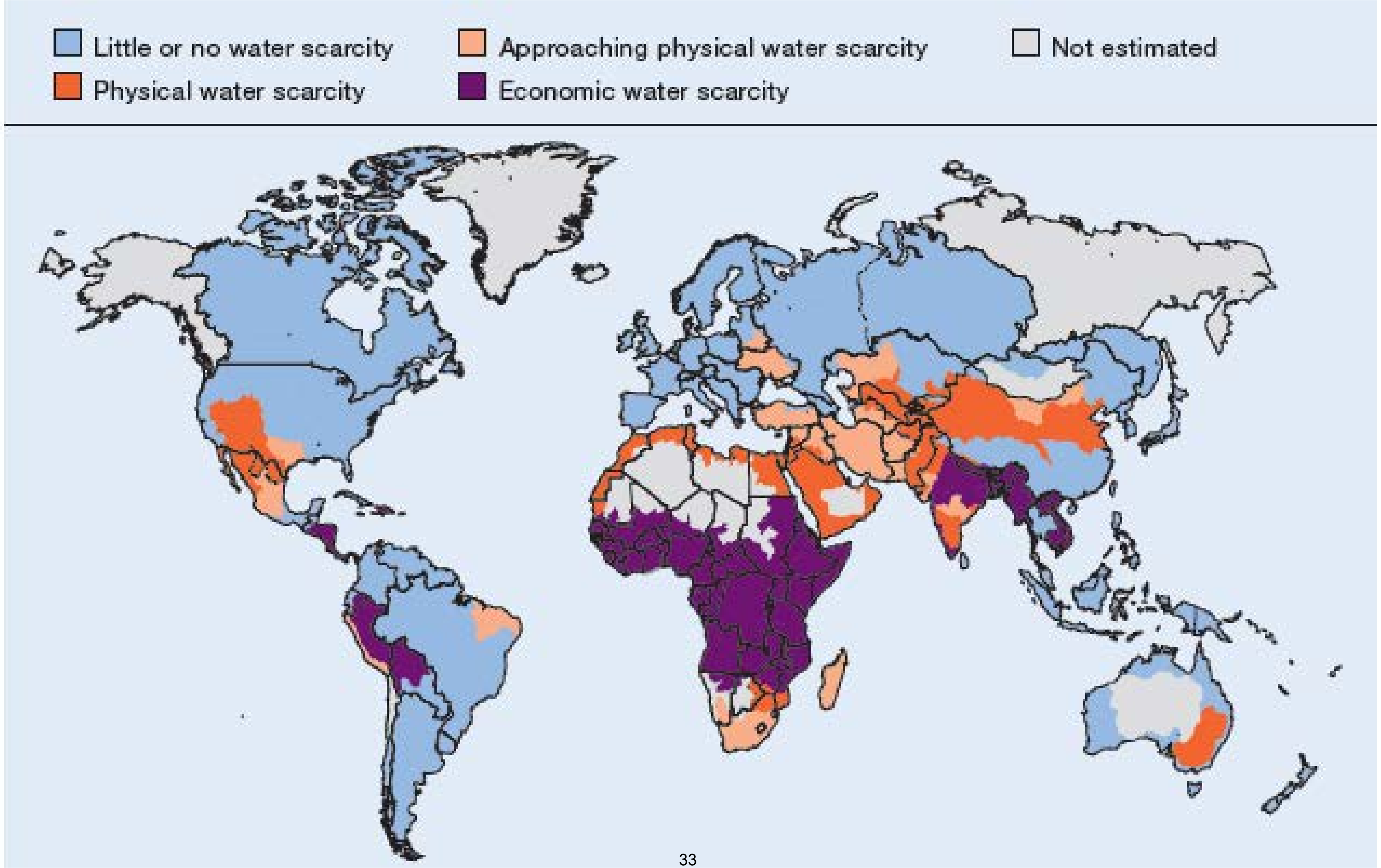


*Physical water stress is defined here as the ratio of total freshwater withdrawn annually by all major sectors, including environmental water requirements, to the total amount of renewable freshwater resources, expressed as a percentage.

Source: UN (2018a, p. 72, based on data from AQUASTAT). © 2018 United Nations. Reprinted with the permission of the United Nations.

https://unesdoc.unesco.org/ark:/48223/pf0000367306

Physical and Economic Water Scarcity, 2007



Different levels of water consumption per capita in different parts of the world

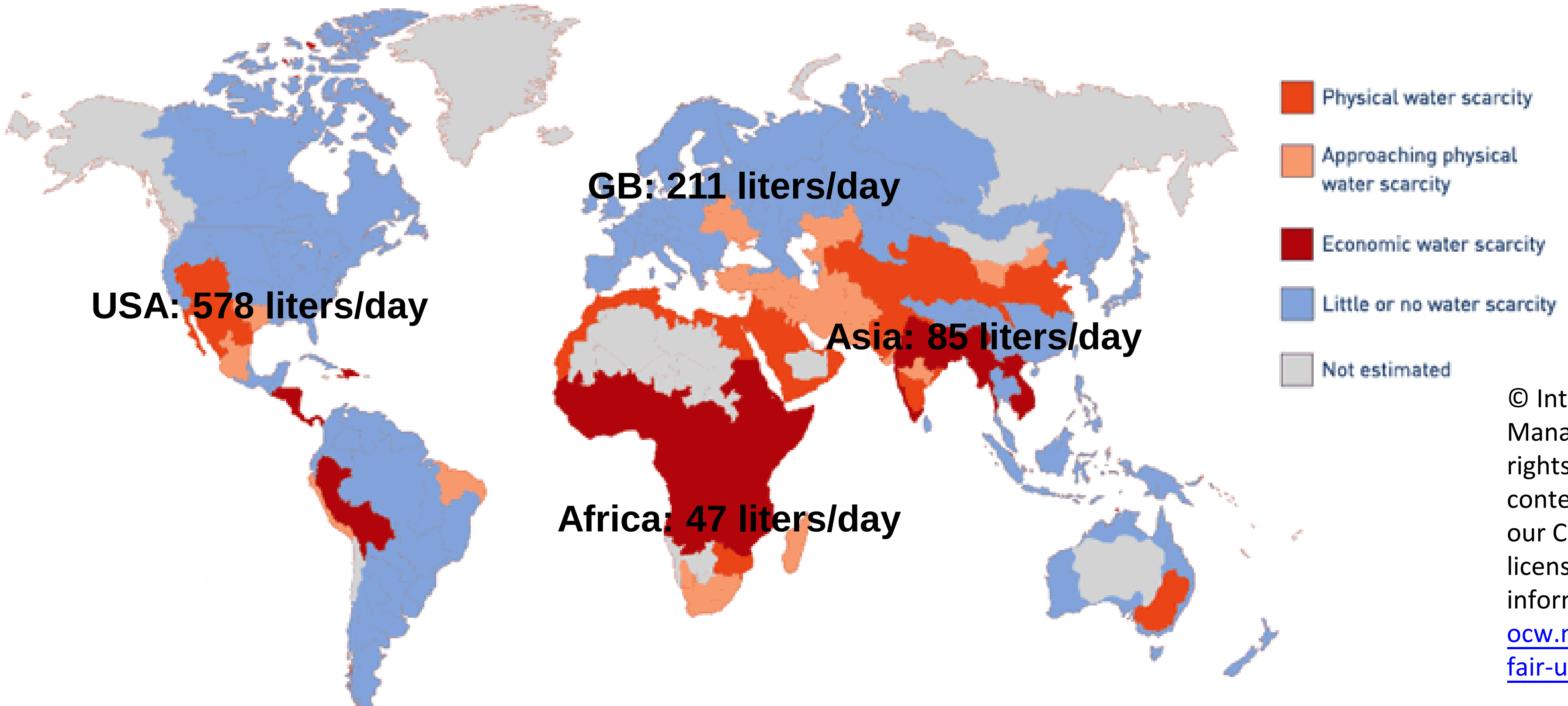
AREAS OF PHYSICAL AND ECONOMIC WATER SCARCITY

Physical water scarcity water resources development is approaching or has exceeded sustainable limits). More than 75% of the river flows are withdrawn for agriculture, industry, and domestic purposes (accounting for recycling of return flows). This definition—relating water availability to water demand—implies that dry areas are not necessarily water scarce.

Approaching physical water scarcity. More than 60% of river flows are withdrawn. These basins will experience physical water scarcity in the near future.

Economic water scarcity (human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human demands). Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition exists.

Little or no water scarcity. Abundant water resources relative to use, with less than 25% of water from rivers withdrawn for human purposes.



Source: Comprehensive Assessment of Water Management in Agriculture, 2007

What is a water footprint?

Water Footprint

- Sum of the volume of water a person uses both directly and in the production of food, commercial goods and services.
- It is the water each person requires for drinking, hygiene and growing food which is is a minimum of 1,000 m3/day.

Country	Water Footprint (m3/person/year)
USA	2,500
Japan	1,150
China	700

www.waterfootprint.org

Water Footprint

	Liters of water needed to produce
1 cup coffee	140
1 liter milk	1,000
1 kg wheat	1,350
1 kg rice	3,000
1 kg corn	9,000
1 kg beef	16,000

Geography of Droughts

Source: Adapted from PBL Netherlands Environmental Assessment Agency (2018, p. 16). Licensed under Creative Commons Attribution 3.0 Unported (CC BY 3.0).

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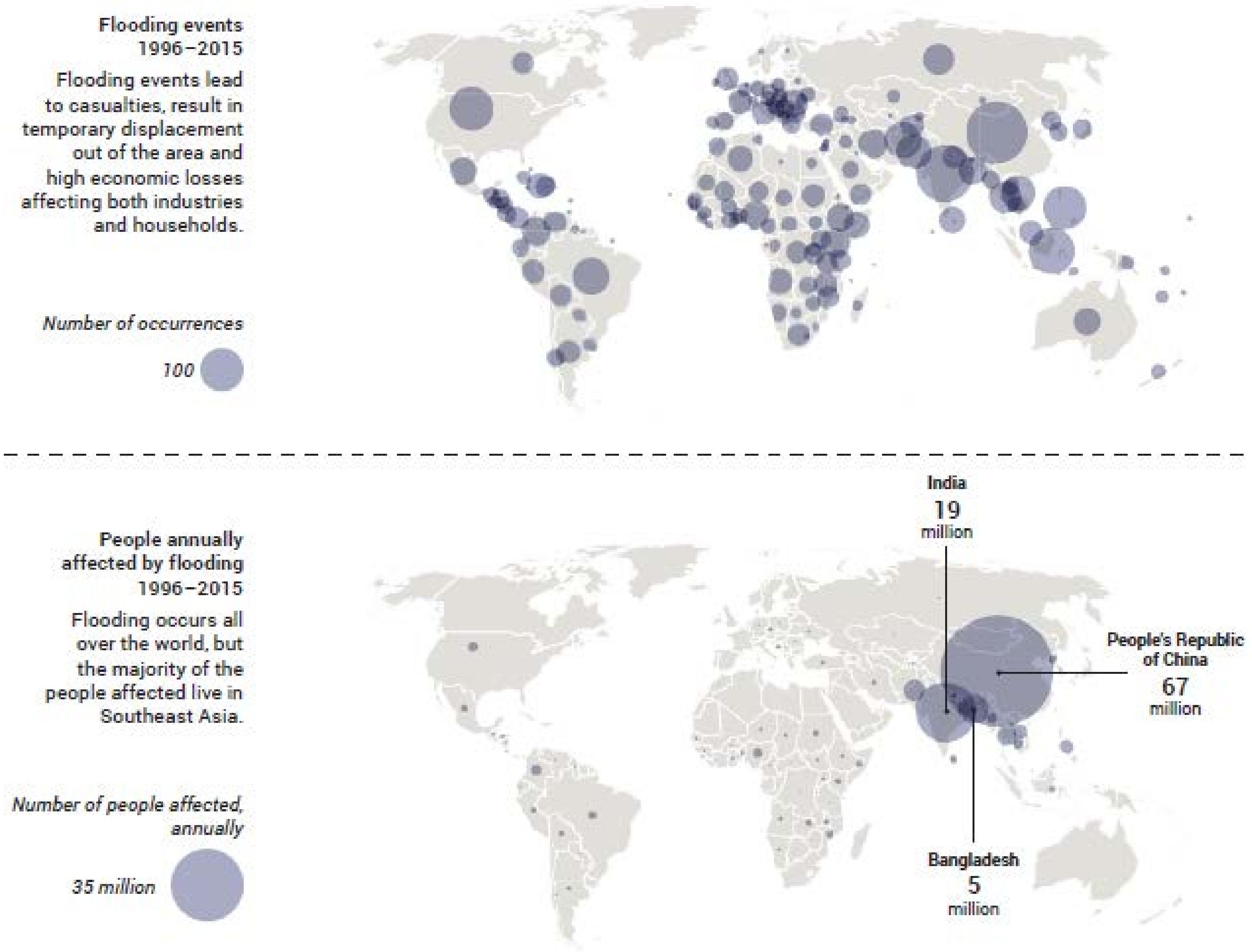
Geography of Floods



Source: Adapted from PBL Netherlands Environmental Assessment Agency (2018, p. 16). Licensed under Creative Commons Attribution 3.0 Unported (CC BY 3.0).

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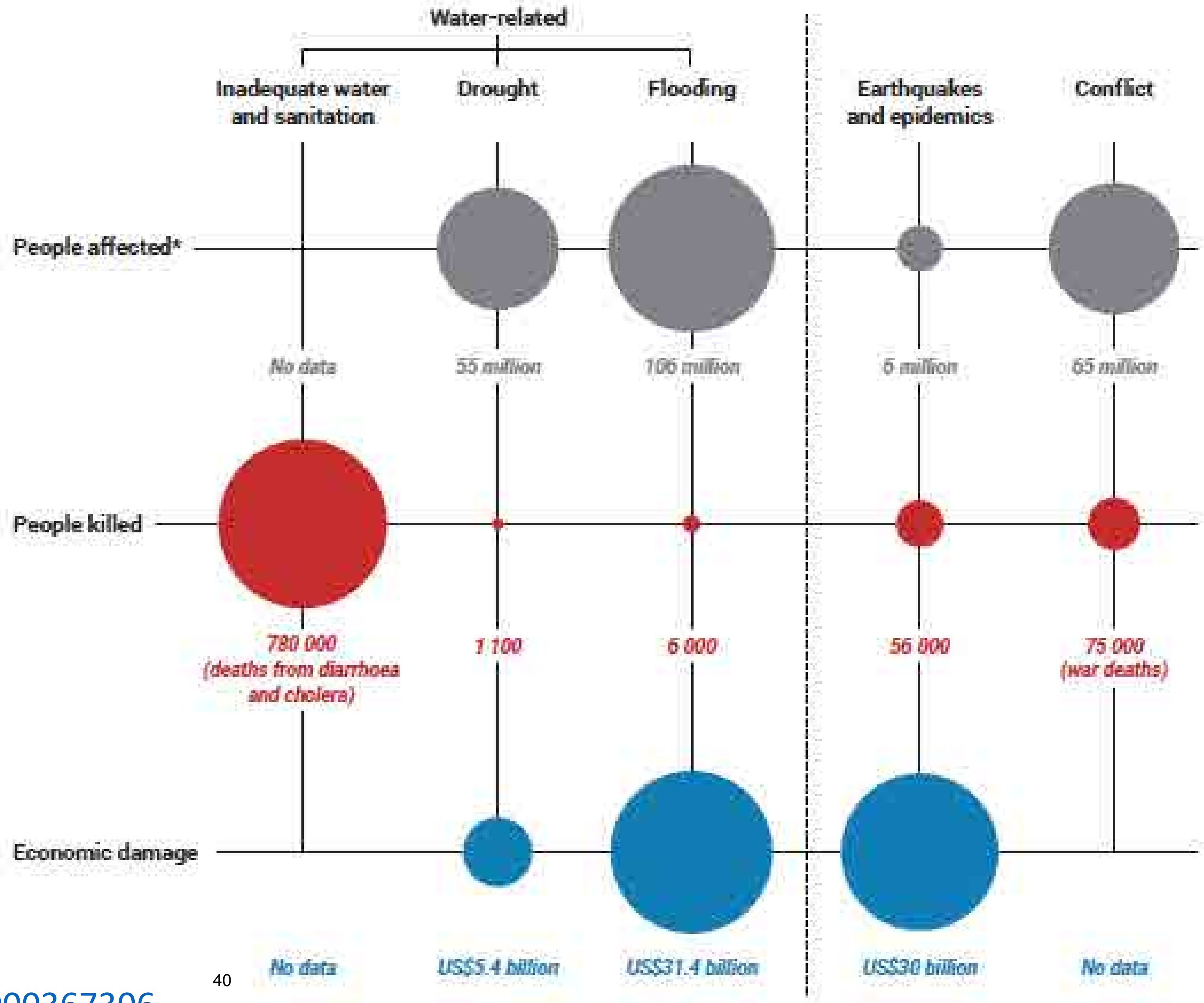
Average annual impact from inadequate drinking water & sanitation services; water-related disasters, epidemics, earthquakes and conflicts



*People affected are defined as those requiring immediate assistance during a period of emergency; this may include displaced or evacuated people.

Source: Adapted from PBL Netherlands Environmental Assessment Agency (2018, p. 14). Licensed under Creative Commons Attribution 3.0 Unported (CC BY 3.0).

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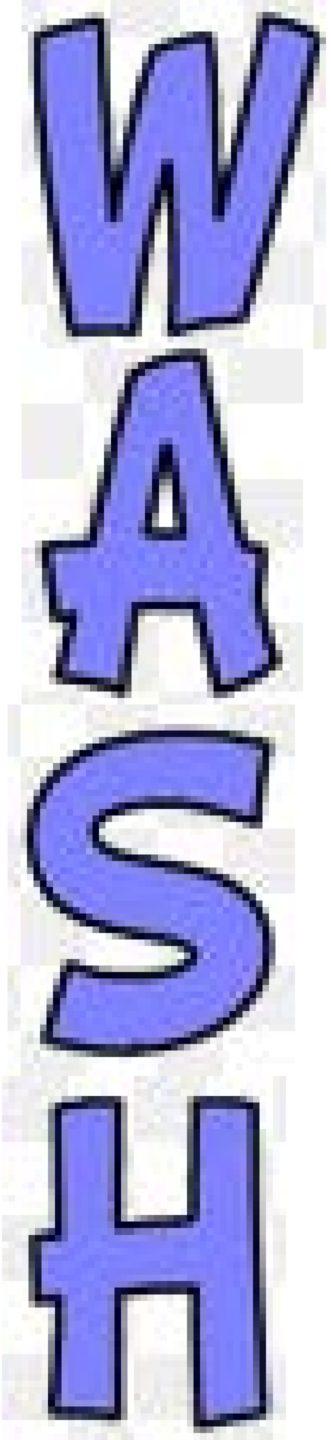
INTRO to WASH

W A S H

“WASH” is the acronym we use to describe one major field within the broader domain of public health and environmental engineering.

In the 19th c. it was called “Sanitary Engineering.”



= water

=sanitation

= hygiene

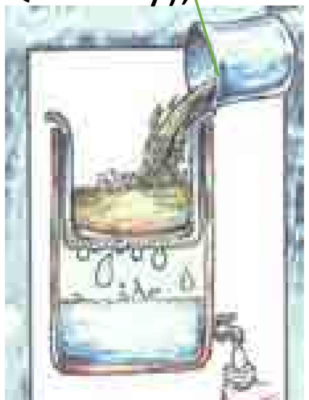
+ ENV

ENVIRONMENT

Focus on overall sanitary condition of the home & the living environment. Is it clean and beautiful or is completely trashed and dirty, as in this slum village Kibera in Kenya

Water Sanitation Hygiene Environment

Water Supply (Quantity), Water Treatment (Quality)



Sanitary Engineering from Ellen Swallow Richards to 21c MIT

In the 19th c. WASH was referred to as "Sanitary Engineering

Ellen Swallow Richards

(1842-1911), MIT's 1st woman graduate, pioneer in the fields of "Sanitary Chemistry and Engineering" and women's STEM education. She was one of the founders of this field in the U.S.

This image is in the public domain.

Public Health Engineering (AKA "Environmental Engineering")

- Application of fundamentals in chemistry, biology, mathematics, physics, engineering, sustainability science, economics, social sciences to protect human health and the environment.

- The field has its origin in public health, which in the USA began at Harvard-MIT School of Health Officers in 1913.

William Thompson Sedgwick

1885 - 1921

Image is in the public domain.

Other MIT luminaries, William Sedgwick and George Whipple, co-founded the Harvard School of Public Health, (originally known as "Harvard-MIT School for Health Officers). Sedgwick called ESF his "great teacher."

- 1883 – 1921: MIT Associate Professor (1884), tenured Professor (1891) and later as Dept. Head of Biology and Public Health at MIT
- 1922: Founding of the Harvard School of Public Health, which originates from a collaboration between Harvard and MIT known as the Harvard-MIT School for Health Officers, the 1st professional training program in public health in the USA, begun in 1913.
- First president of the Society of American Bacteriologists (now American Society for Microbiology) in 1899-1901.

George C. Whipple

1866 - 1924

Image is in the public domain.

1888-1889: Whipple studied sanitary chemistry under E.S. Richards.
1889: Graduated MIT majoring in chemistry and microbiology.
1889 – 1897: in charge of the Chestnut Hill Laboratory at today's Waterworks Museum

My own contributions to global safe water have been partly inspired by the example of Ellen Swallow Richards.

Ellen Swallow Richards

Susan sharing safe water fr. Kanchan Filter

USA – 3 Top Causes of Death 1900 vs 2000

Top Three Causes of Death

1900

1. Pneumonia and flu
2. Tuberculosis
3. Infectious diarrhea

2000

1. Heart disease
2. Cancer
3. Stroke

Q: Why do you think infectious diseases are no longer leading causes of death in the USA?

Infectious diseases were well-known in the Boston area families of both my maternal grandmother and mother-in-law

Polio – 1908 (Beverly MA)

Helen Hillary (1892 – 1978)

Typhoid – 1914 (Winthrop, MA)

Edith Helen Coffman (1907 – 2004)

In 1998, I began mentoring teams of MIT students in public health engineering projects, focused on water, sanitation, hygiene & environmental challenges working in ≈ 20 low-income countries.

2nd Intern'l Women & Water Conference - Kathmandu, Nepal

September 1998

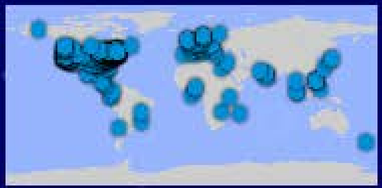
Donate to H2O-1B

Search H2O-1B

Safe Water For 1 Billion People

GLOBAL WATER & SANITATION PROJECTS

MIT M.ENG. H_2O-1B	DOCUMENTS	MIT	GLOBAL



TECHNOLOGIES

- Household Treatment
- Water Supply
- Water Treatment
- Sanitation
- Hygiene

IN THE NEWS

MEDIA

STUDENT BLOGS

WATSAN FACEBOOK

COURSES

- MIT OpenCourseWare (Murcott)
- MIT Water Courses
- Global Water Courses

WEBLINKS

GLOBAL WATER MAPPING

- Drinking Water Supply & Treatment Mapping
- Sanitation Mapping

INTERNATIONAL HWTS NETWORK

- HWTS Network Tools
- HWTS Monitoring & Evaluation
- Network Conference Proceedings

METHODS

- Water Quality Standards & Guidelines
- Low Cost Field Testing
- Microbiological
- Physical
- Chemical
- Radiological
- Surveys
- Units of Measurement

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

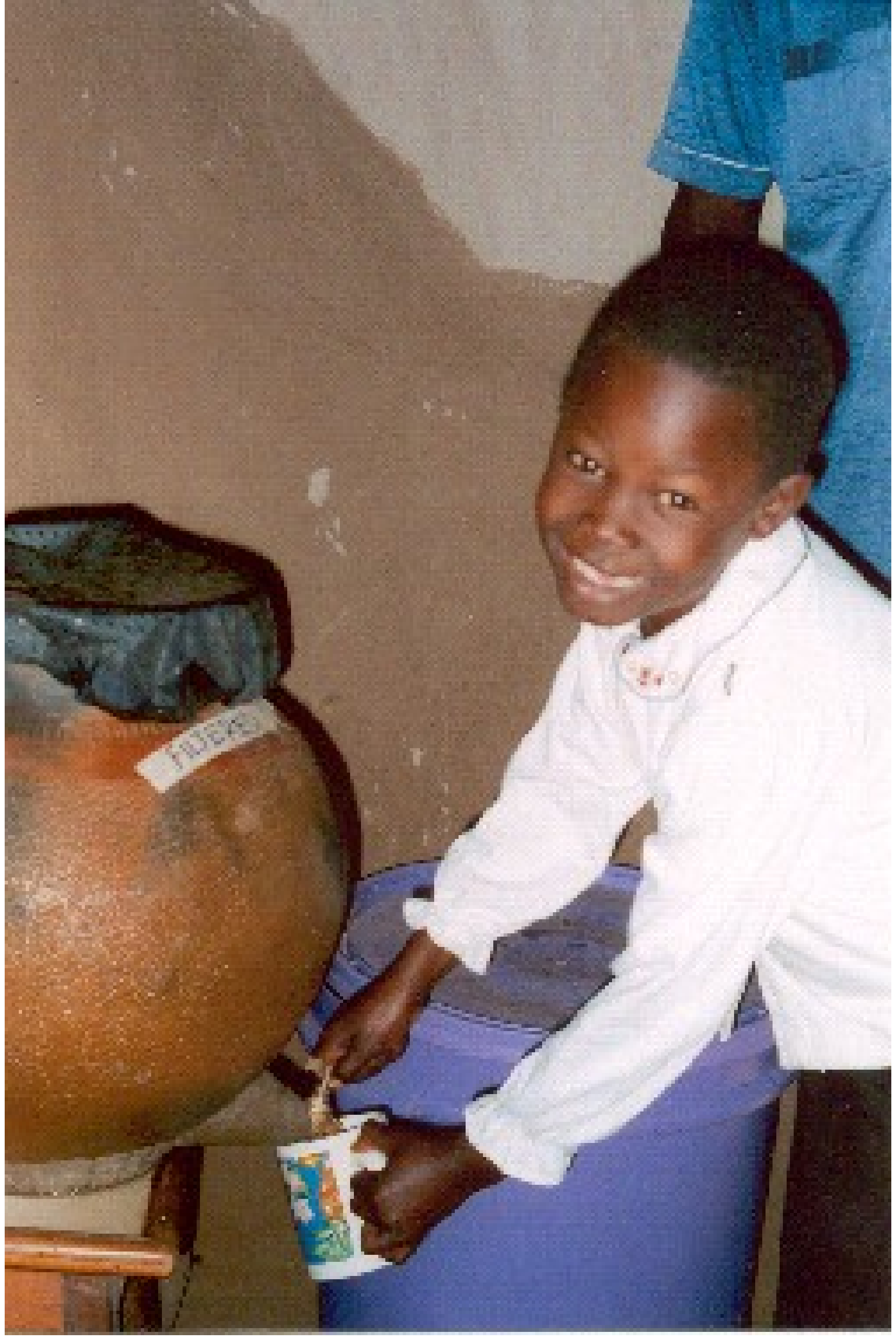
http://web.mit.edu/watsan

Safe Water for 1 Billion People

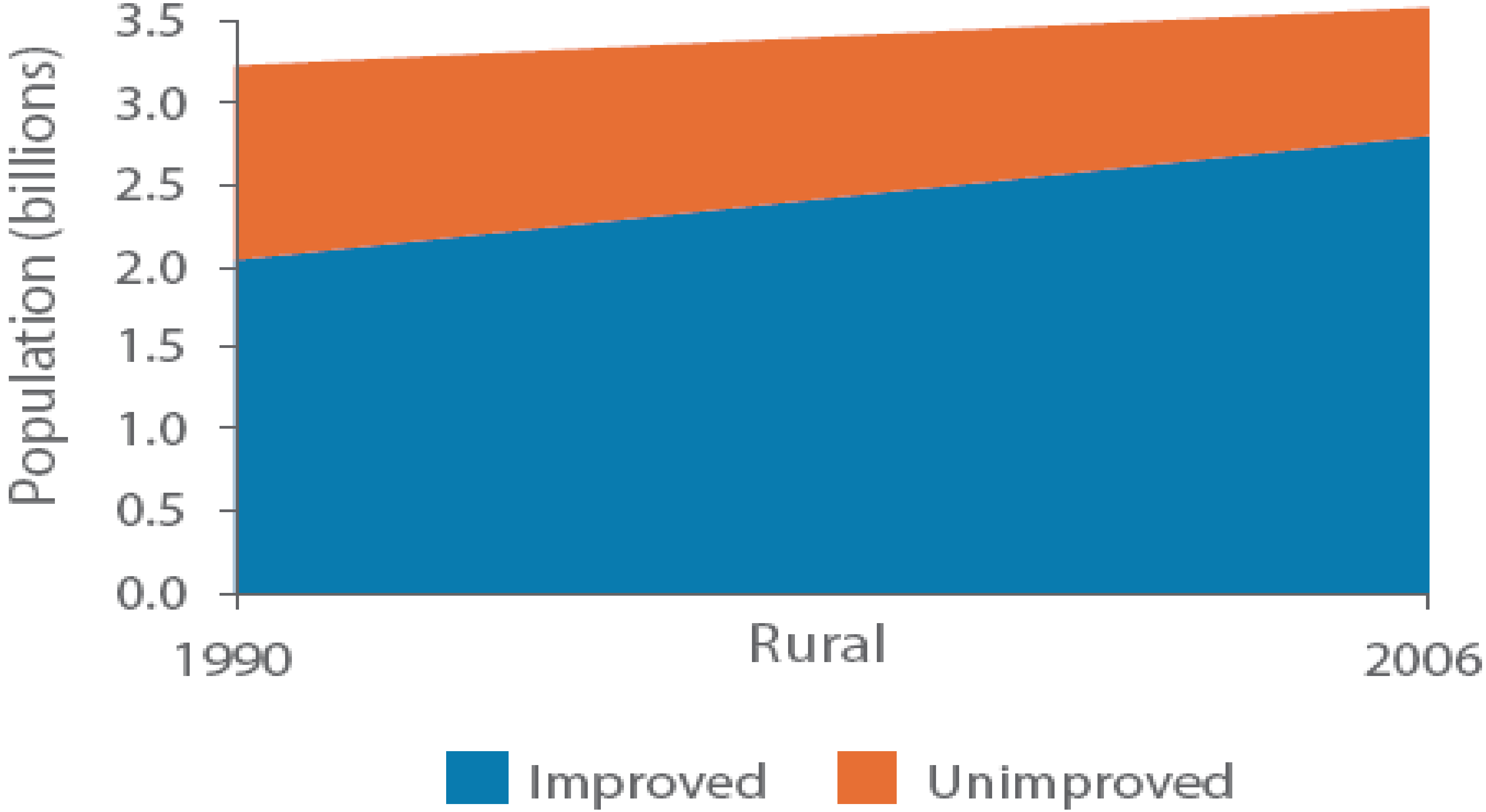
(H2O-1B)

Project-based, service projects targeting the bottom 1/7 of humanity = “the bottom billion”

(Started in 1998)



746 million people in rural areas use unimproved water supplies



Rural Drinking Water Coverage 1990 - 2006 (UNICEF/WHO, 2008)

Women and children are the ones most profoundly impacted by water pollution and water scarcity.

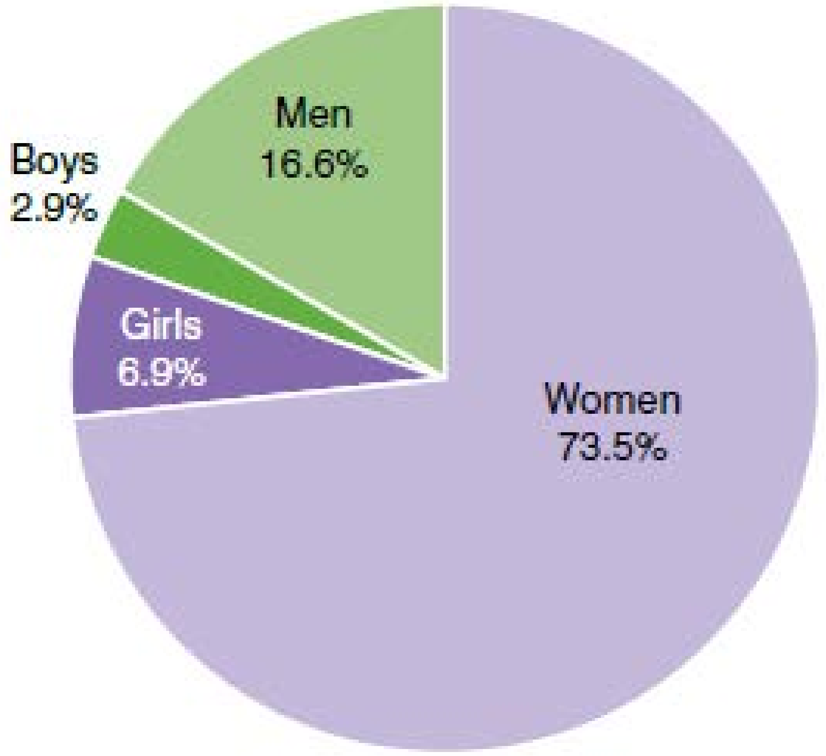
They also live in urban / peri-urban slums.

More than 152 million hours of women and girls' time is consumed per day collecting water for domestic use -

UNICEF/WHO, 2010

Women & girls have largest burden of collecting water

Women and girls are responsible for water collection in 8 out of 10 households with water off premises



- Reference: UNICEF, WHO. Safely Managed Drinking Water Thematic Report, 2017. p. 30.
- Based on the JMP's analysis of MICS and DHS data for the *Women's World Report* in 2015.
- Shows that the burden of hauling water falls disproportionately on women.
- In 53 out of 73 countries, over half of households with water off premises rely on women to collect water.
- In a few countries (e.g., Mongolia), men are primarily responsible, and in 14 countries, the burden also falls on children, with a boy or girl under 15 primarily responsible in at least 1 in 10 households.

(UNICEF / WHO, 2017)

Millennium Development Goals (MDGs) (2000-2015) & Sustainable Development Goals (SDGs) (2016 – 2030)

Millennium Development Goals & Targets

Goal 1: Eradicate extreme poverty and hunger

Goal 2: Achieve universal primary education

Goal 3: Promote gender equality and empower women

Goal 4: Reduce child mortality

Goal 5: Improve maternal health

Goal 6: Combat HIV/AIDS, malaria and other diseases

Goal 7: Ensure environmental sustainability

Goal 8: Develop a global partnership for development

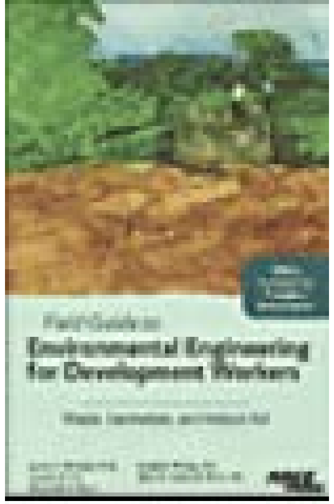
http://www.un.org/millenniumgoals/

MDG – Goal 7 - Target 3

Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation

http://www.un.org/millenniumgoals/environ.shtml

Definitions of Improved and Unimproved Water Supplies (2000)



Unimproved Water Supplies	Improved Water Supplies
Unprotected wells	Household connections
Unprotected springs	Public standpipes
Vendor-provided water	Boreholes
Bottled water	Protected dug wells
Tanker-truck provided water	Protected springs

Note: Bottled water is considered unimproved because of possible problems of sufficient quantity, not quality.

Source: WHO 2000.

From Field Guide for Development Workers, Ch. 9. Figure 9-3. p. 163.

Drinking Water & Sanitation Ladders

(UNICEF/WHO, 2012)

Surface Water	• All surface waters (rivers, streams, dams, lakes, ponds, canals, irrigation channels)
Unimproved	• Unprotected dug wells & springs • Tanker trucks and carts • Vended water
Other Improved	• Public taps • Tube wells & boreholes • Protected dug wells & springs • Rainwater harvesting
Piped Supply on Premises	• Household connection inside or outside user's dwelling

OPEN DEFECATION	**Open defecation:** Defecation in fields, forests, bushes, bodies of water or other open spaces, or disposal of human faeces with solid waste.
UNIMPROVED	**Unimproved sanitation facilities:** Facilities that do not ensure hygienic separation of human excreta from human contact. Unimproved facilities include pit latrines without a slab or platform, hanging latrines and bucket latrines.
SHARED	**Shared sanitation facilities:** Sanitation facilities of an otherwise acceptable type shared between two or more households. Shared facilities include public toilets.
IMPROVED	**Improved sanitation facilities:** Facilities that ensure hygienic separation of human excreta from human contact. They include: • Flush or pour-flush toilet/latrine to: - piped sewer system - septic tank - pit latrine • Ventilated improved pit (VIP) latrine • Pit latrine with slab • Composting toilet.

“Improved” Water ≠ Safe Water

- The U.N. 2015 estimate is that 663 million people (9%) use “unimproved” sources.

- Onda et al (2012) estimated an additional 1.2 billion (18%) use water from sources or systems “with significant sanitary risks.”

- Total lacking **<u>safe water</u>** ≈ 1.8 billion people according to these data from 2012 & 2015.

Reading Assignment: 2017 "SDG Progress on WASH"

- On September 25th 2015, 193 member countries adopted a set of goals to **end poverty**, **protect the planet**, and **ensure prosperity for all** as part of a new sustainable development agenda.
- Each goal has specific targets to be achieved over the next 15 years.

http://www.un.org/sustainabledevelopment/sustainable-development-goals/

SDG Goal 6 – Clean Water and Sanitation

http://www.un.org/sustainabledevelopment/sustainable-development-goals/

SDG Global Goals, Targets and Indicators for Drinking Water, Sanitation & Hygiene (WASH)

https://data.unicef.org/wp-content/uploads/2017/07/JMP-2017-report-launch-version_0.pdf

WASH Sector Goal	SDG Global Target	SDG Global Indicator
Progress towards safely managed services	6.1 By 2030, achieve universal and equitable access to **safe and affordable drinking water** for all.	6.1.1 Population using **safely managed drinking water services**
	6.2 By 2030, achieve access to **adequate and equitable sanitation and hygiene** for all and **end open defecation**, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1 Population using **safely managed sanitation services** 6.2.1 Population with a basic **handwashing facility** with soap and water available on premises

Safely managed drinking water is defined as:

- Located on premises
- Available when needed
- Free from fecal contamination and priority chemical contamination (e.g. arsenic and fluoride)

SDG Global Goals, Targets and Indicators for Drinking Water, Sanitation & Hygiene (WASH)

WASH Sector Goal	SDG Global Target	SDG Global Indicator
Ending open defecation	6.2 (same as above)	6.2.1 Population practicing **open defecation**

https://data.unicef.org/wp-content/uploads/2017/07/JMP-2017-report-launch-version_0.pdf

Q: How many people worldwide lack a safely managed drinking water service*?

* (i) Located on premises;
(ii) Available when needed;
(iii) Free from contamination (compliant with standards for fecal coliform, arsenic and fluoride = “priority chemical contamination”).

≈ 2.1 billion people (29%)

7.3 billion (global population in 2015)

- 5.2 billion (population using a safely managed drinking water service (71%)

≈ 2.1 billion people

https://data.unicef.org/wp-content/uploads/2017/07/JMP-2017-report-launch-version_0.pdf

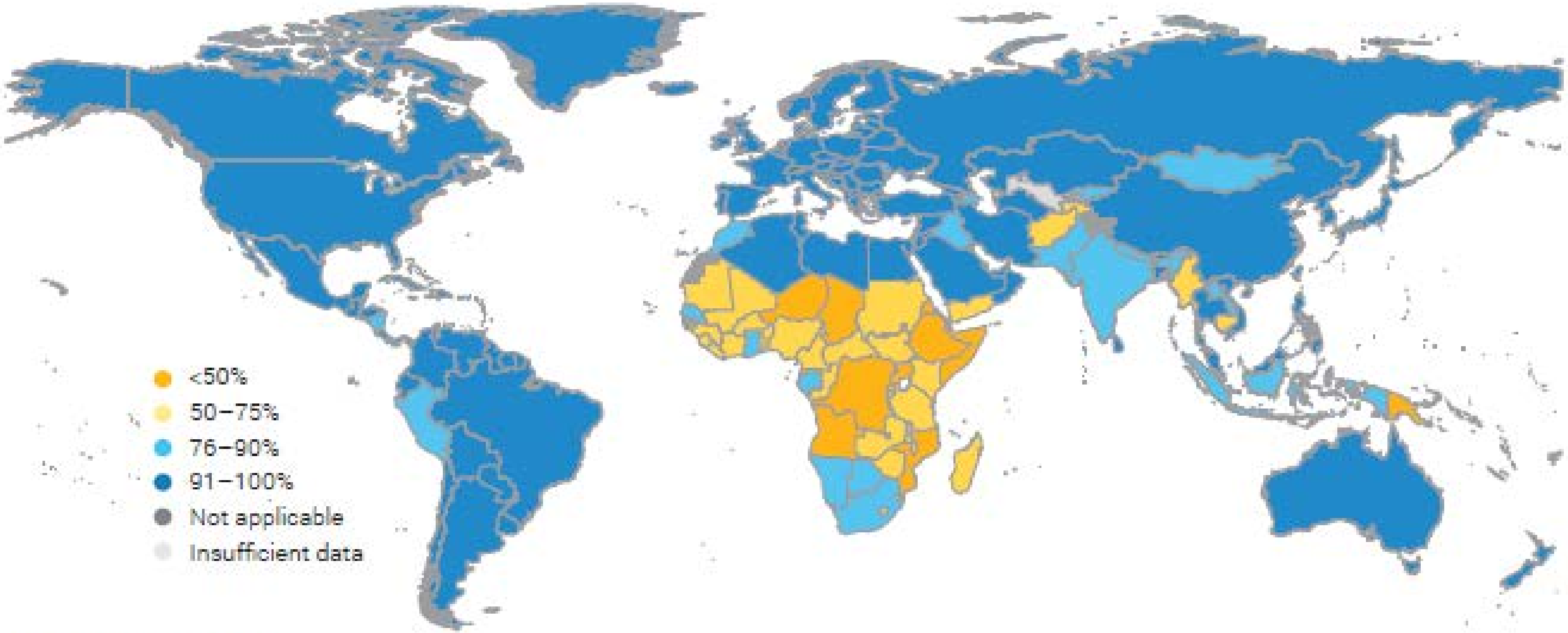
New JMP Ladder for Drinking Water

SERVICE LEVEL	DEFINITION
SAFELY MANAGED	Drinking water from an improved water source that is located on premises, available when needed and free from faecal and priority chemical contamination
BASIC	Drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip, including queuing
LIMITED	Drinking water from an improved source for which collection time exceeds 30 minutes for a round trip, including queuing
UNIMPROVED	Drinking water from an unprotected dug well or unprotected spring
SURFACE WATER	Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal

Note: Improved sources include: piped water, boreholes or tubewells, protected dug wells, protected springs, and packaged or delivered water.

https://data.unicef.org/wp-content/uploads/2017/07/JMP-2017-report-launch-version_0.pdf p.8

Proportion of population using at least basic drinking water services, 2015



Source: WHO/UNICEF (2017a, fig. 4, p. 3).

New JMP Ladder for Sanitation

SERVICE LEVEL	DEFINITION
SAFELY MANAGED	Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated offsite
BASIC	Use of improved facilities that are not shared with other households
LIMITED	Use of improved facilities shared between two or more households
UNIMPROVED	Use of pit latrines without a slab or platform, hanging latrines or bucket latrines
OPEN DEFECATION	Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches or other open spaces, or with solid waste

Note: improved facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines; ventilated improved pit latrines, composting toilets or pit latrines with slabs.

https://data.unicef.org/wp-content/uploads/2017/07/JMP-2017-report-launch-version_0.pdf p.8

Q: How many people in the world lack safely managed sanitation services?

≈ 4.4 billion people (60%)

7.3 billion (global population in 2015)

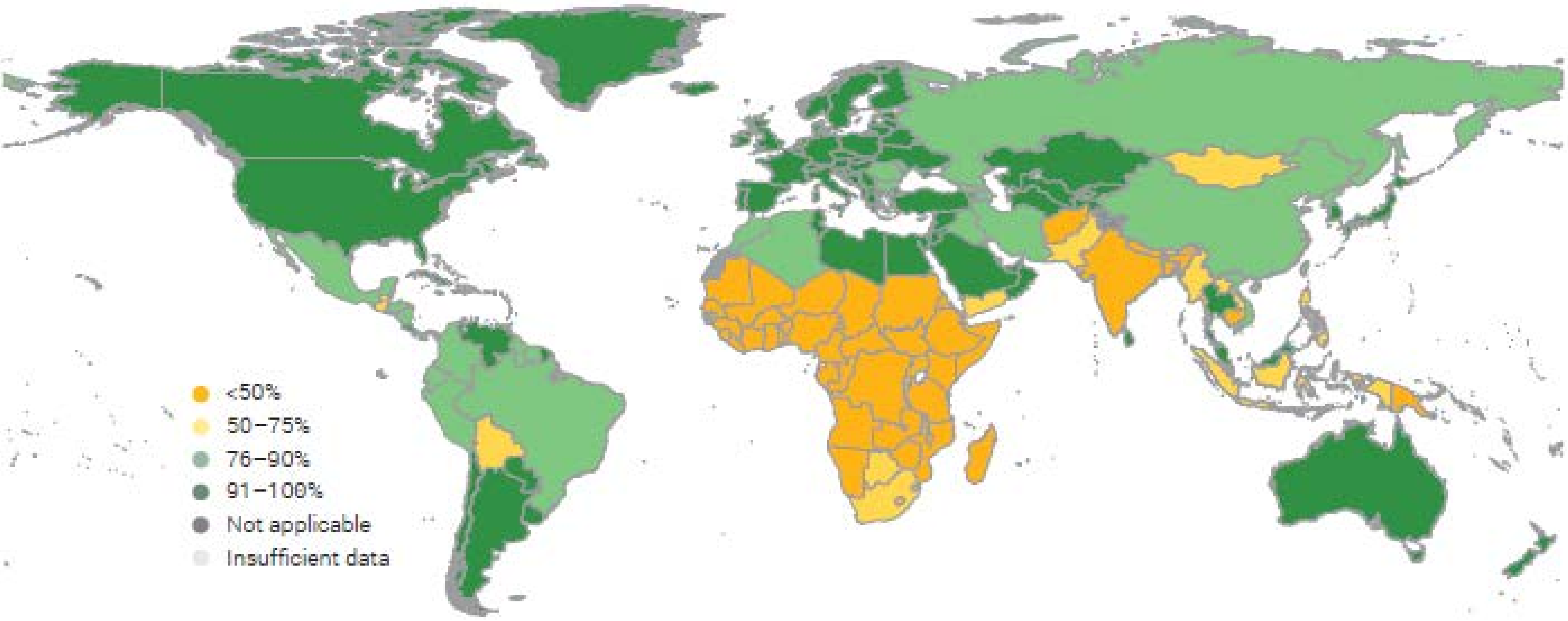
+ 2.9 billion (population using a safely managed sanitation service (p.3)

≈ 4.4 billion people

but the same UN report gives even higher #s (p.29)

https://data.unicef.org/wp-content/uploads/2017/07/JMP-2017-report-launch-version_0.pdf p.3

Proportion of population using at least basic sanitation services



Source: WHO/UNICEF (2017a, fig. 7, p. 4).

Q: How many people worldwide lack basic hand-washing facility with soap and water on premises?

We don't know!

(global data currently insufficient)

Regional Handwashing Facilities Data

Region	% Population lacking handwashing facilities with soap & water on premises
Western Asia and Northern Africa	24%
SubSaharan Africa	85%

https://data.unicef.org/wp-content/uploads/2017/07/JMP-2017-report-launch-version_0.pdf p.5

What has happened since the MDG goals were established at the beginning of the 21st Century?

Water as a Human Right Defined…

- “The human right to water entitles everyone to **sufficien**t, **safe**, **acceptable**, **physically accessible** and **affordabl**e water for personal and domestic uses.” (UN Committee on Economic, Social and Rights, 2002

Water as a Human Right

- But the U.N. General Assembly vote in July 2010 did not make the right to water legally binding.
- Then, UN Human Rights Council General Council, in a landmark decision in August 2010, agreed that
  - “The right to water and sanitation is contained in existing human rights treaties and is therefore legally binding.”
- But, while recognized in international law, this legislation is not enforceable at the national level until it is incorporated into national law.

What is happening after 2015?

Terminology

Human Right to Water Terminology	Post-2015 Monitoring Drinking Water Group Terminology	Equity, Equality, Non-discrimination
Sufficient & continuous	Availability (including quantity and reliability)	Quantity
Safely managed	Water quality, including acceptability	Quality, Acceptability
Physically accessible & within reach	Accessibility	Accessibility • Physically accessible • Reliable
Affordable	Affordability	Affordability

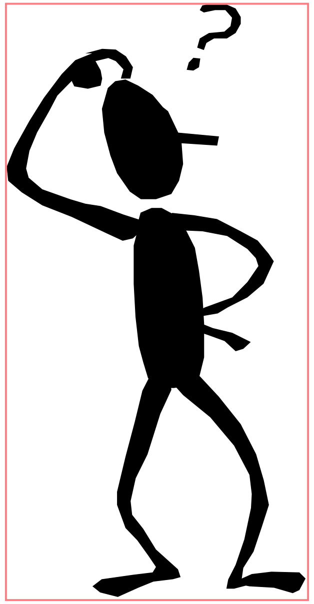
Equity, Equality
&
Non-discrimination

Our ultimate goal?

- Human Right to Water, Sanitation, Hygiene and a Safe Environment!

- Equity, equality and non-discrimination as it relates to water, sanitation, hygiene, environmental well-being.

- Across all countries and population segments (income groups, ethnic groups, gender, age groups, special needs).



D-Lab calls this “Creative Capacity Building” which means design and development

EVERYONE!

Development &

Development &

Development &

Universal piped water treated to drinking water standards… Is that the goal?

- Humanity requires water for multiple uses. In high-income countries, all domestic water, whether for drinking, bathing, car washing or yard irrigation is ALL treated to drinking water quality standards and is available 24/7.

- In regions where water is scarce, and safely managed drinking water, i.e. for 1/3 of humanity, one logical approach might be to match the water type to the water use.

- For example, graywater could be re-used for irrigation, car washing, and other uses

What might be the goals and trade-offs for someone who is water poor?

A person might collect water from a pathogen contaminated pond that is nearby and no cost vs. a pathogen-free source, say, a borehole well that is 30 minutes away, where one has to pay for the water. The health benefits may be a lower priority to that person than time and money savings.

More Info on D-Lab

DLab-WASH Class (Fall 2019) –

WASH & Susan’s work

DLab: http://d-lab.mit.edu/about/people/susan-murcott

Videos:

http://globalwater.mit.edu/videos

References

- Bartram, J. Ed. Routledge Handbook of Water and Health. Taylor and Francis, 2015
- Brown, L. 1993. State of the World. World Watch Institute. W.W. Norton and Co. New York.
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Annex 1

Pictures showing examples of unimproved and improved water supplies

Unimproved Water Supplies

(as defined by the WHO-UNICEF Joint Monitoring Programme)

- Unprotected well;
- Unprotected spring;
- Vended water (includes bottled and bagged water)
- Tanker Truck water
- All surface waters

Unprotected Well – Hand Dug Well

- Hand dug well
  - Most common
  - Low capital costs, but labor-intensive
  - Dangerous to construct without proper skills
  - 1.5-2.0 m diameter, 10-30 m deep
  - Pump not a feature of an “unprotected” dug well

Unprotected Well - Burma

Unprotected Springs

Vended Bottled (or Bagged) Water

Vended Tanker Truck Water

Surface Water - Ghana

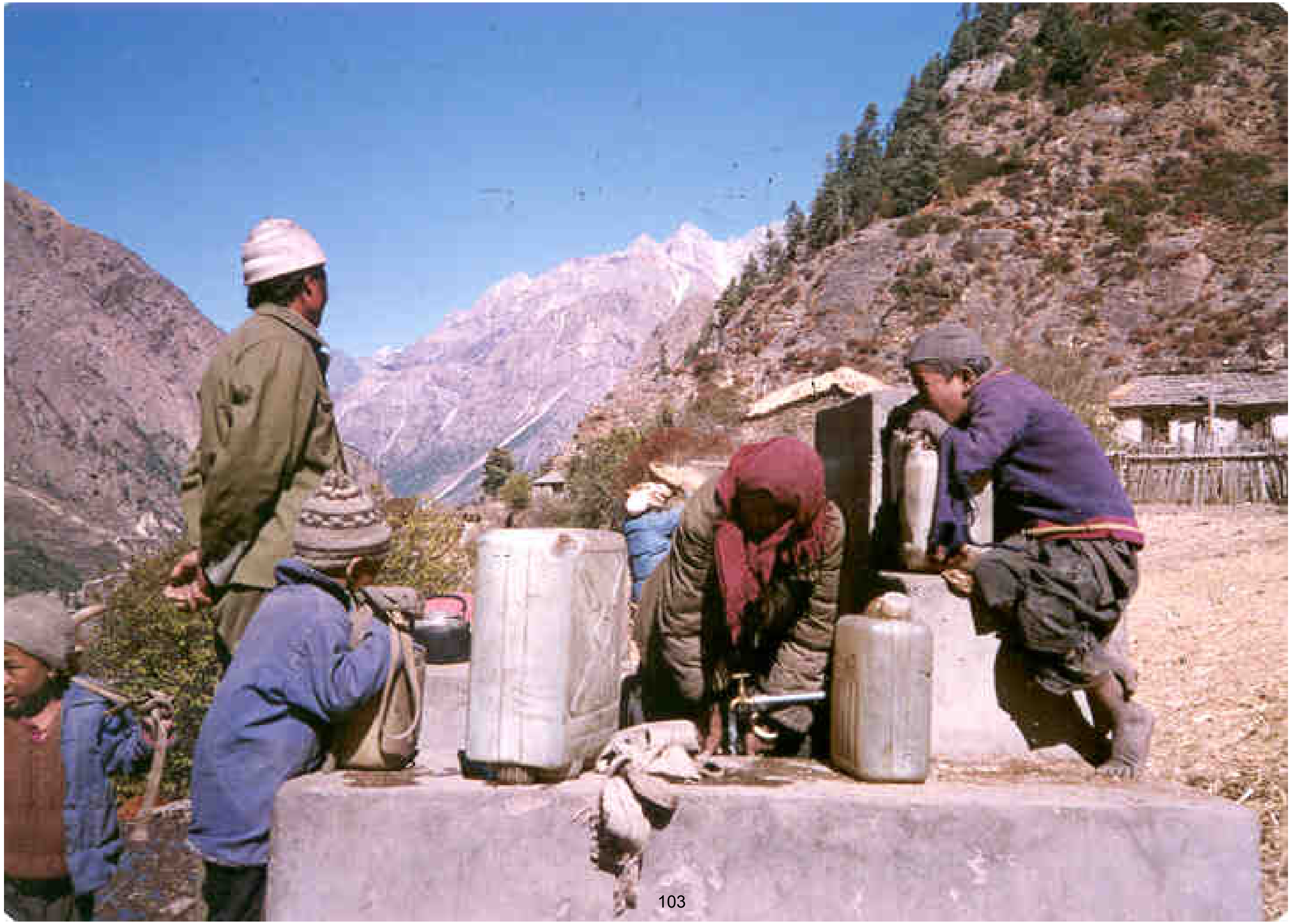
Surface Water – Stream - Nepal

Improved Water Supplies

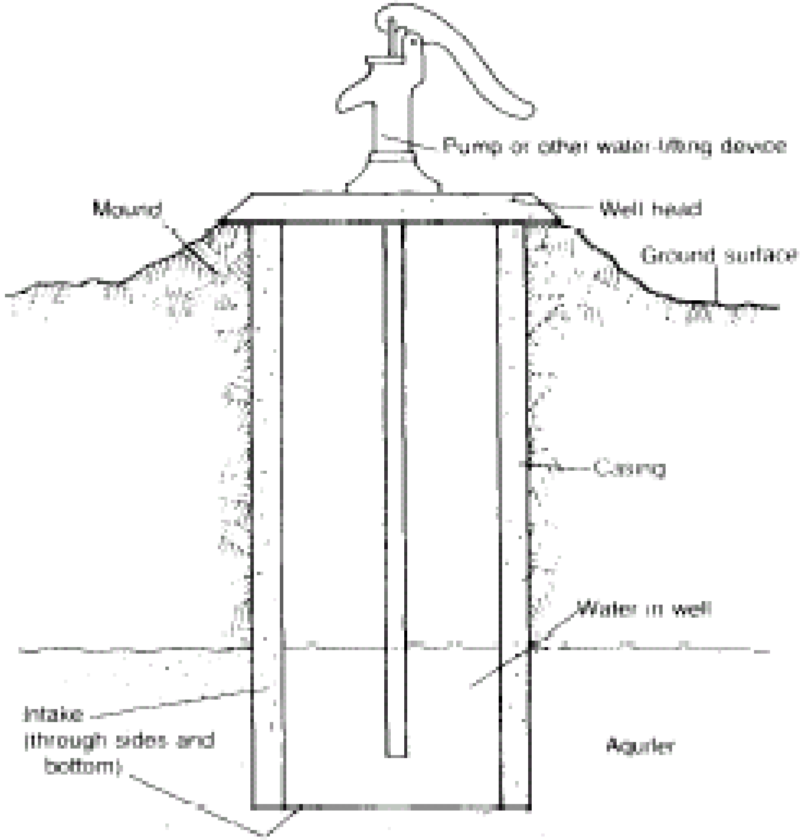
(as defined by the WHO-UNICEF Joint Monitoring Programme)

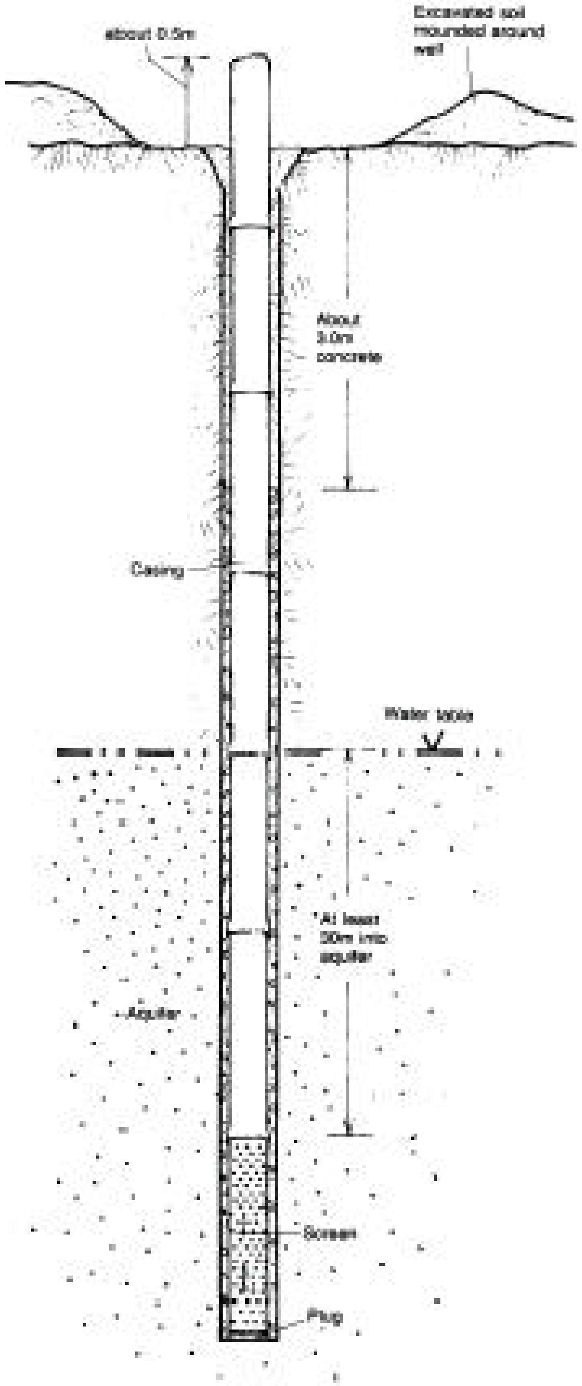
- Public standpipe
- Borehole (drilled well)
- Protected dug well
- Protected spring
- Rainwater harvesting
- Household connection
  - Outside the home
  - Inside the home

Public Standpipe



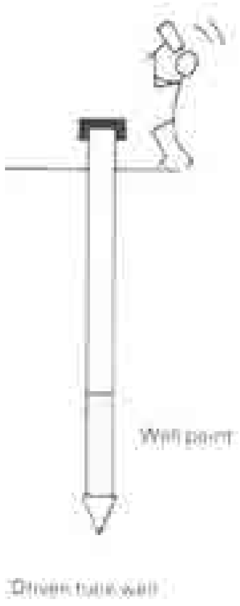
General Well Design (Hand Dug or Drilled)

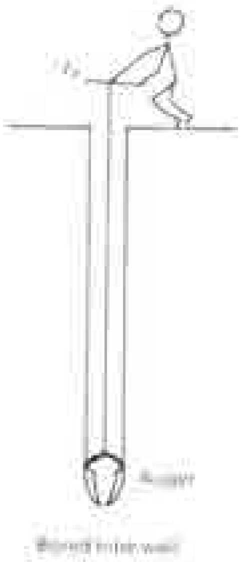




Drilled Well Types

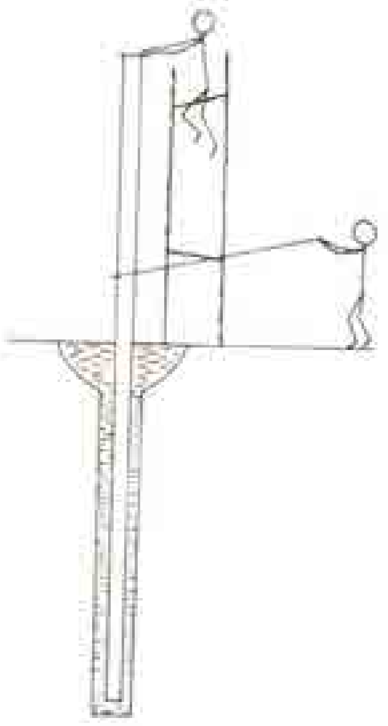
- Driven tube well
  - Perforated tube with well point driven into ground with hammers, pile drivers, etc.
  - 5-10 cm diameter, 15-20 m deep
  - Pump required due to small diameter
  - Generally last ~5 years as well points clog or rust
- Bored tube well
  - Dug with auger (hand or mechanical)
  - Soil must be cohesive or can use casing
  - Pack area around well screen with gravel to improve recharge
  - 10-25 cm diameter, 20-40 m deep
  - Pump required due to small diameter

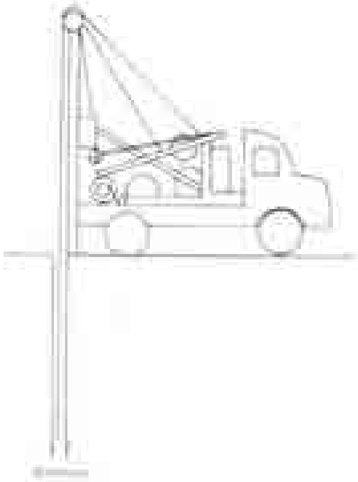




Well Types

- Jetted tube well
  - Tube jetting into soft material
  - Soil removed from hole as sediment-laden water flows out top
  - 10-25 cm diameter, up to several hundred m deep
  - Pump required due to small diameter
  - Usually cased
- Bore hole wells
  - Require mechanical drilling rig
  - Rotary-type drills most common
  - 15-30 cm diameter, can be drilled deep as required
  - Pump required due to small diameter
  - Usually cased unless in bedrock





(Jetted) Tubewell - Nepal

A “Protected” Well

A well equipped with:

- Handpump;
- Concrete Platform;
- Drainage Channel;

Still, “protected wells” can have problems…

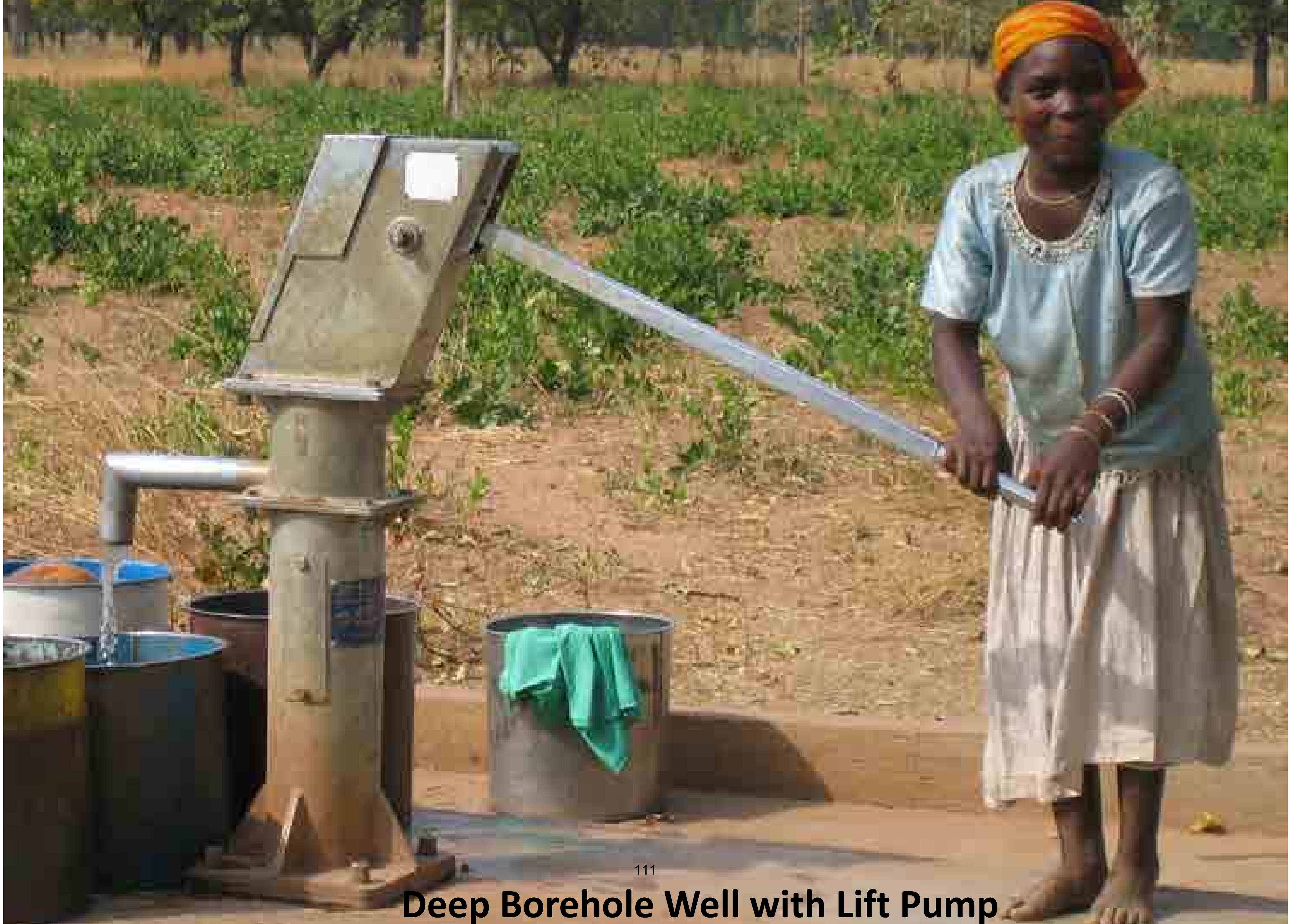
- Broken apron;
- Broken handpump;
- Use of dirty water to prime the well;
- Flooding during monsoon;
- Improper siting;
- Poor drainage

Broken handpump

Broken apron

(Photos: Yongxuan Gong,MIT, 2003)

Machine-drilled Borehole Construction



Deep Borehole Well with Lift Pump

Deep Borehole Well
with Lift Pump

Hand Pumps

Shallow well pumps

- Pumping mechanism above ground
- Water pulled up by suction
- Limited to vertical distance of 7-8 m

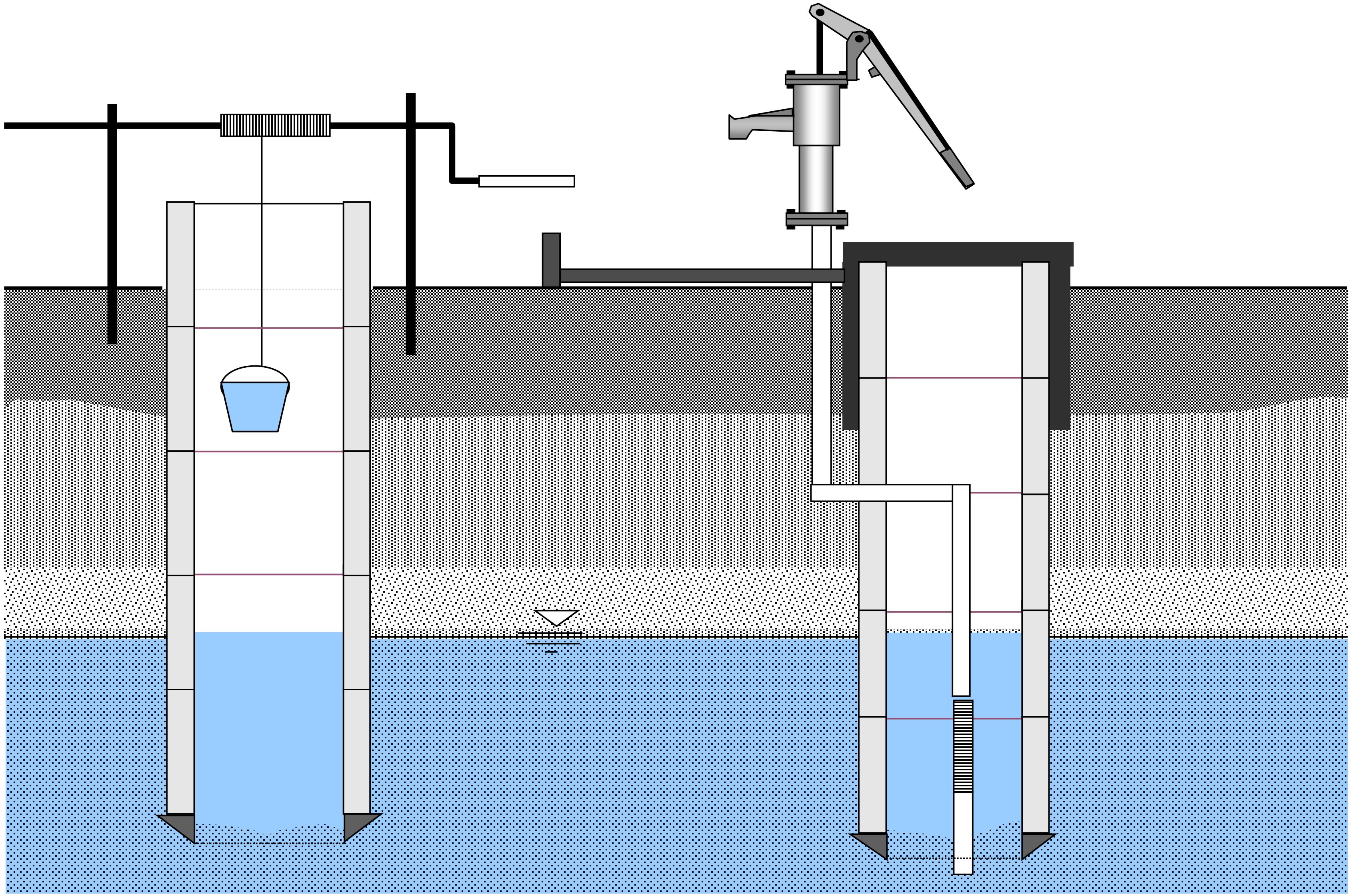
Deep well pumps

- Pumping mechanism inside the well
- Water pushed up by piston
- Entire mechanism must be pulled out for maintenance (3-5 times per year)
- Can raise water from great depths

Characteristics of a Good Hand Pump

- Simple and as easy to repair as possible
- Easy to maintain – low maintenance requirements
- Local manufacture, if possible
- Reliable and low cost
- Resistant to abuse, vandalism, theft of parts
- Easy for women and children to use
- Produces water at reasonable rates
- Suitable for local geologic conditions (corrosion, sufficient suction head, etc.)
- Clearly illustrated installation and maintenance instructions
- Basic tools and maintenance kit for repairs

Unimproved and Improved Dug Well



Conventional

Improved

Dug Well Improvements

- Proper Siting
  - least 60 m (preferably uphill) from any source of pollution (latrines, rubbish dumps)
- Headwalls (about 1 m high) and drainage aprons
  - Prevents surface runoff and spilt water from entering well
  - Drainage apron should convey water to soakaway
  - Most important improvement
- Windlass, pulleys, rollers
  - Helps people pull up bucket without dragging it along inside of well
  - May help keep rope and bucket off ground
- Well cover
  – Water tight to prevent pollution entering open top
- Pump or permanent bucket anchored to the well.
- Shock chlorination of well
  - Continuously or periodically
  - May cause taste problems – drive users away

Improved Dug Well

An improved dug well goes from this --->>>

to this --->>>

Improved Dug Well - Ghana

Protected Spring

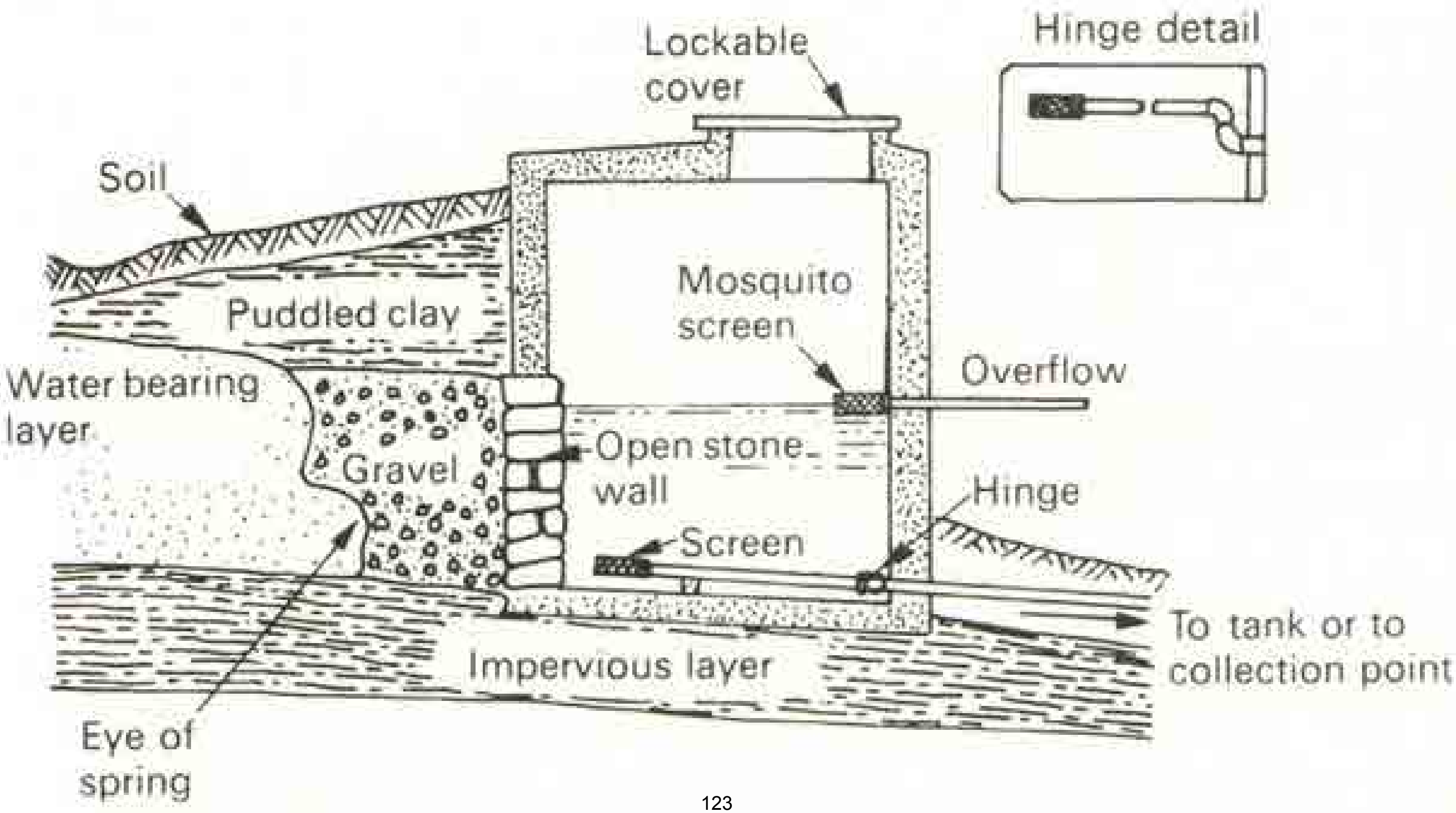
Protected Springs

- Good quality water
- Usually does not require pumping
- Important characteristics
  - Spring box of brick, masonry or concrete to collect water and protect from contamination
  - Permeable back wall to allow water seepage into box
  - Graded gravel or sand over eye to prevent piping and erosion
  - Lockable cover
  - Screened outlet and overflow pipes
  - Do not disturb impermeable base of spring

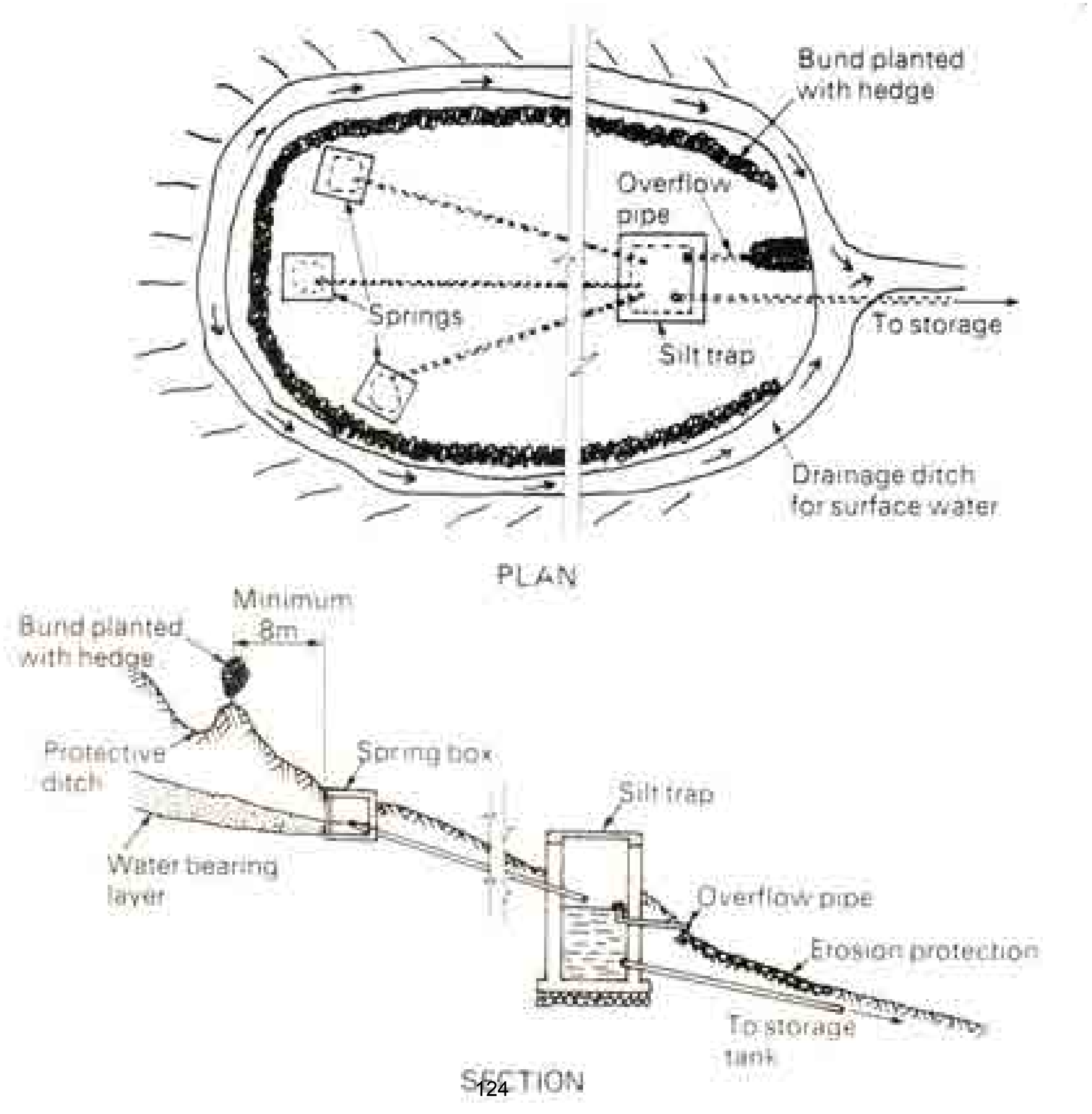
Protected Springs

- Important characteristics, continued
  - Top of spring box > 300 mm above ground level
  - Compact clay around exterior of spring box
  - Divert upslope surface runoff using ditch and bund
  - Fence off spring box with stones, wooden fence, or thorny vegetation
  - Allow for sediment accumulation – place outlet pipe 100 mm above bottom of box
  - Install bottom drain with valve for sediment removal and spring box cleaning

Spring Box Design



Spring Box Design



Unprotected spring!

Rainwater Harvesting

Advantages:

- **Household access;**
- **Free of chemical contamination (e.g. arsenic, fluoride etc.);**
- **Limited susceptibility to microbiological pollution.**
- **Good technology in floods.**

Disadvantages:

- **Seasonality;**
- **Relatively expensive;**
- **People unaccustomed to it**

Piped Water System

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- Photo Credits: Sheila McKinnon "Born Invisible", was presented by the Fondazione Edoardo Garrone at the Palazzo Ducale in Genoa, Italy, Feb. 3, 2011.