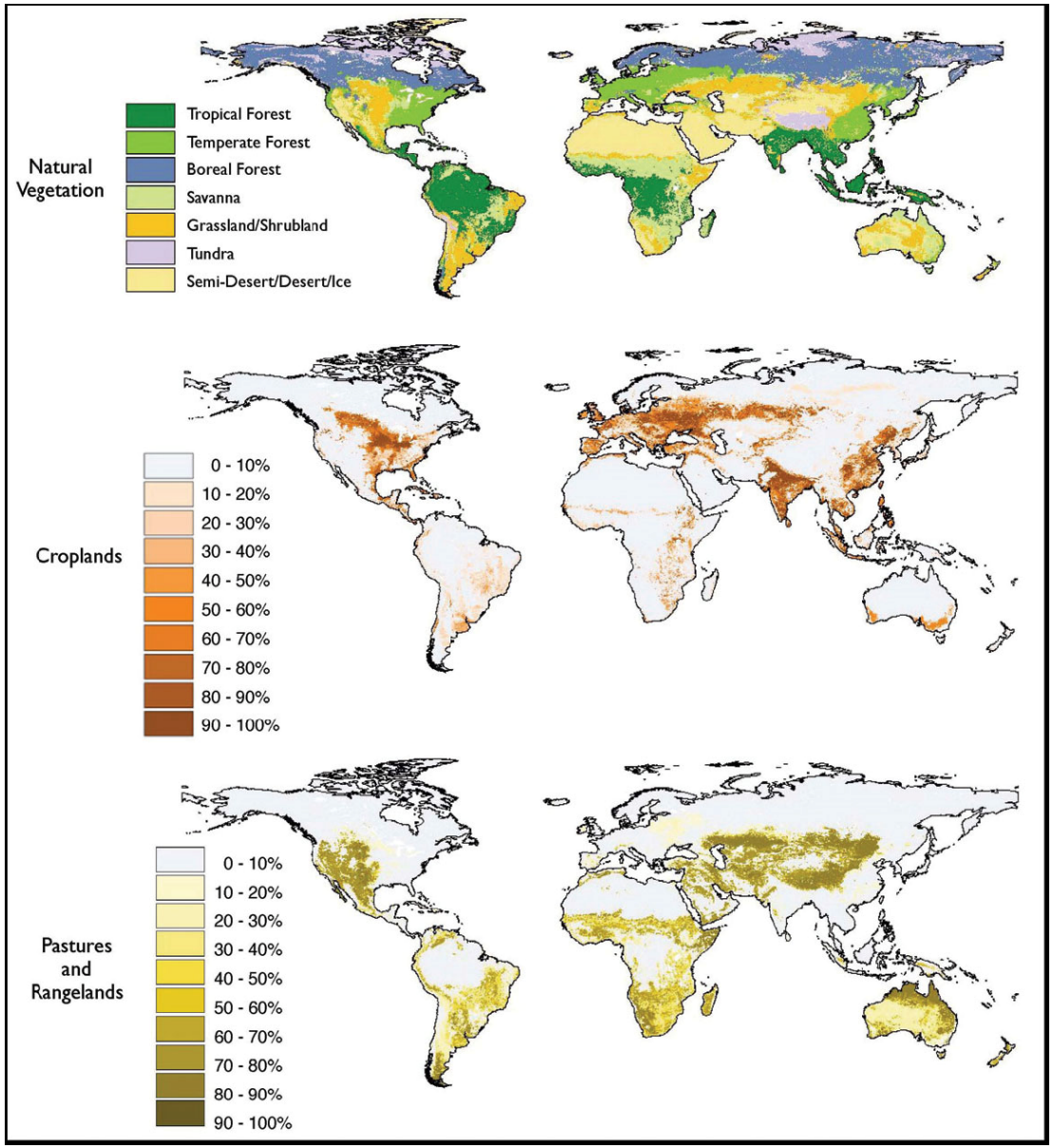
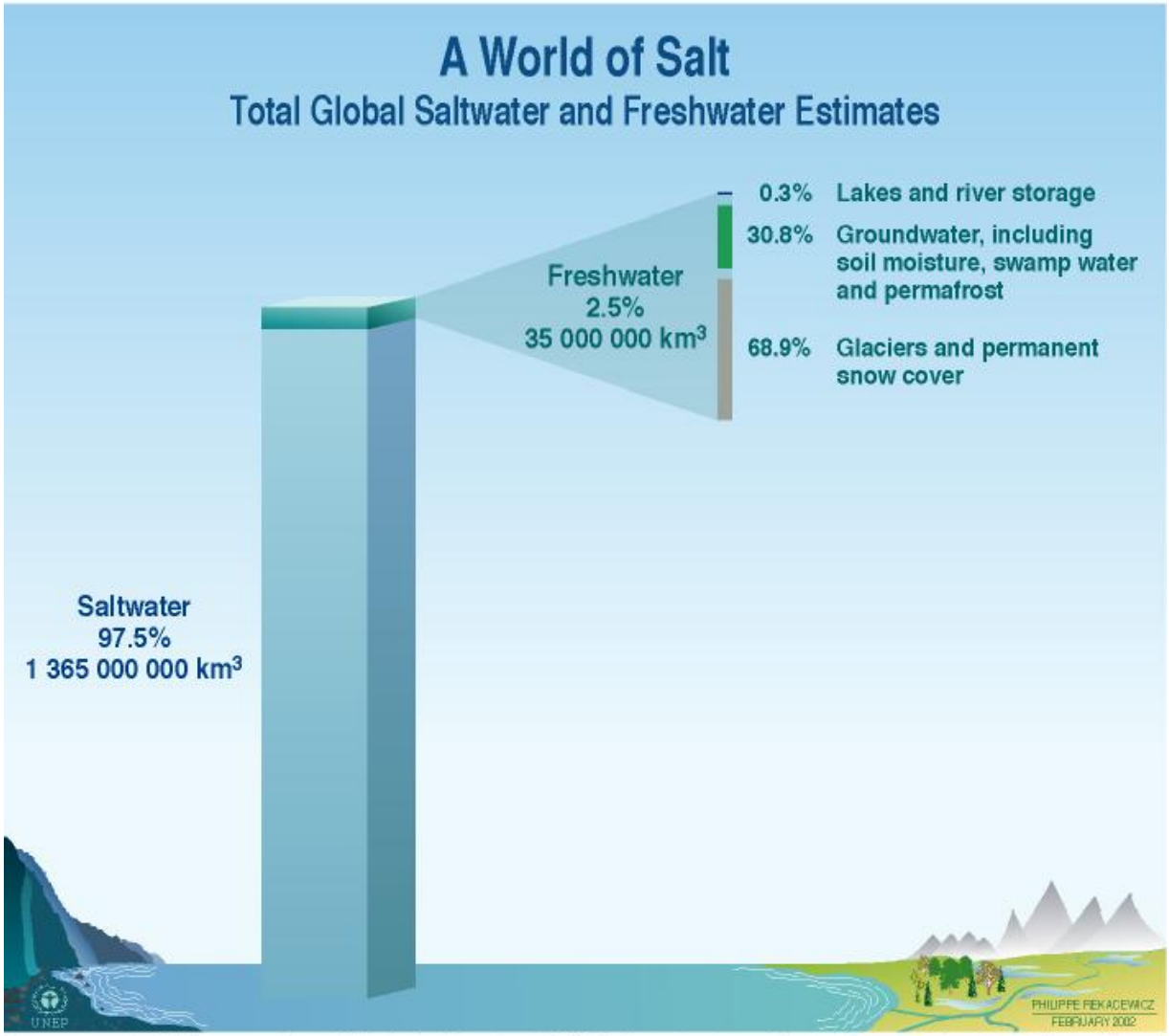
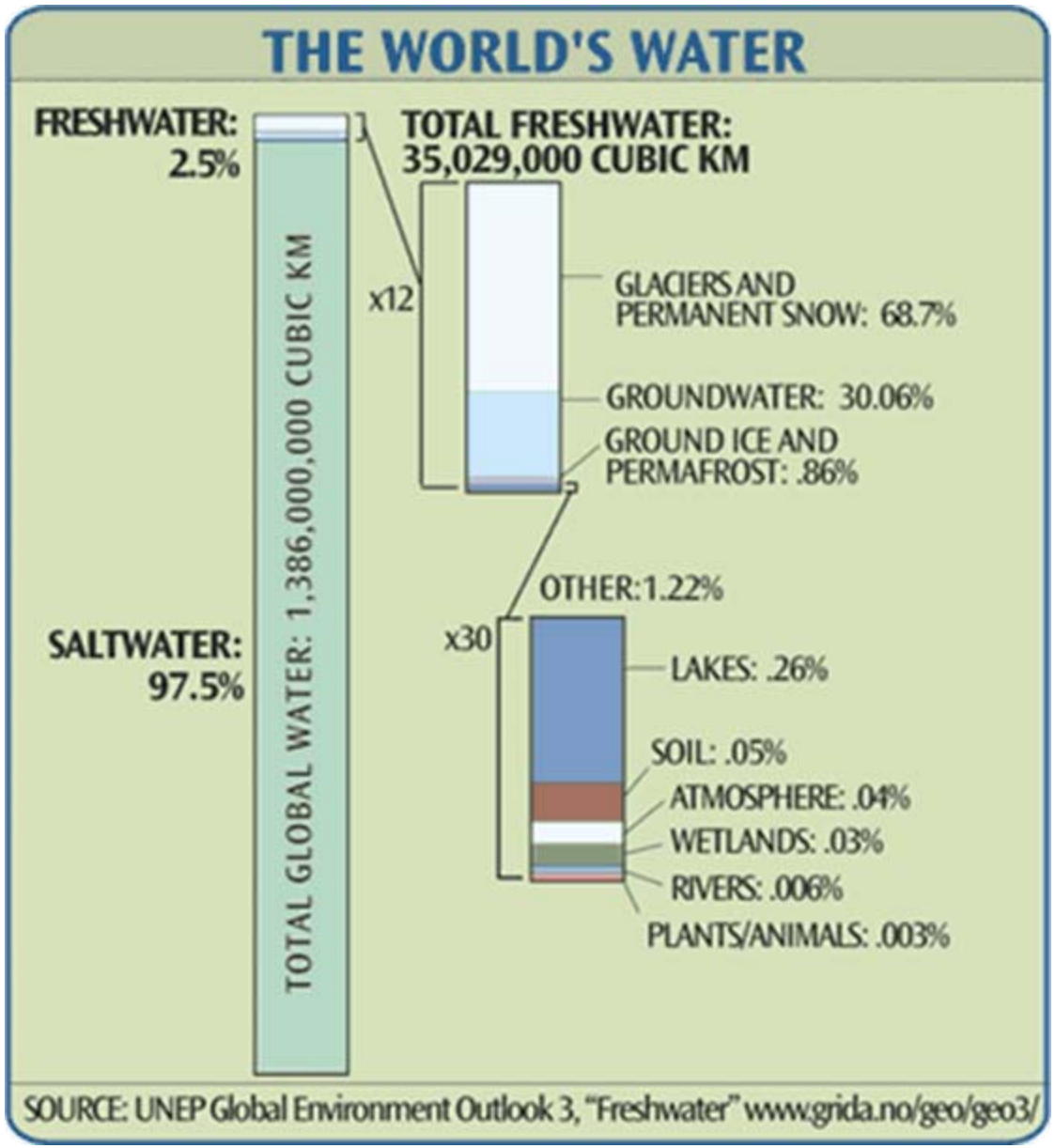
Agriculture and Water

Agriculture’s Water Consumption


Natural Vegetation
Tropical Forest
Temperate Forest
Boreal Forest
Savanna
Grassland/Shrubland
Tundra
Semi-Desert/Desert/Ice
Croplands
0 - 10%
10 - 20%
20 - 30%
30 - 40%
40 - 50%
50 - 60%
60 - 70%
70 - 80%
80 - 90%
90 - 100%
Pastures and Rangelands
0 - 10%
10 - 20%
20 - 30%
30 - 40%
40 - 50%
50 - 60%
60 - 70%
70 - 80%
80 - 90%
90 - 100%



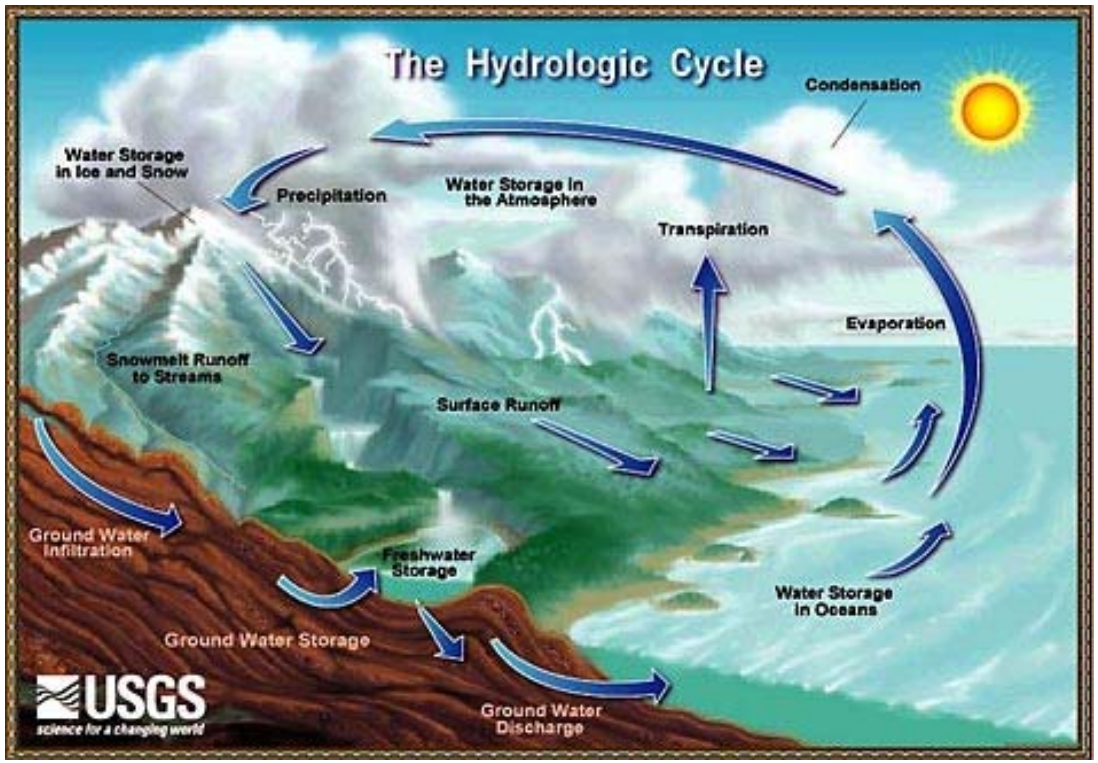
Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999.

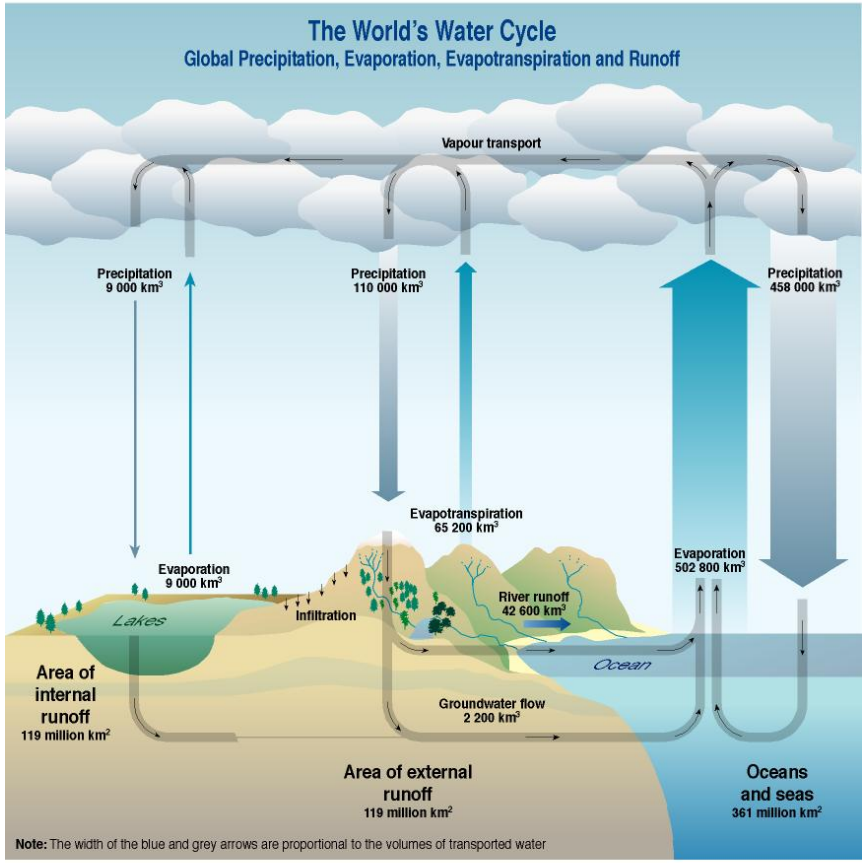

THE WORLD'S WATER
FRESHWATER:
2.5%
SALTWATER:
97.5%
TOTAL GLOBAL WATER: 1,386,000,000 CUBIC KM
TOTAL FRESHWATER:
35,029,000 CUBIC KM
x12
GLACIERS AND
PERMANENT SNOW: 68.7%
GROUNDWATER: 30.06%
GROUND ICE AND
PERMAFROST: .86%
OTHER:1.22%
x30
LAKES: .26%
SOIL: .05%
ATMOSPHERE: .04%
WETLANDS: .03%
RIVERS: .006%
PLANTS/ANIMALS: .003%
SOURCE: UNEP Global Environment Outlook 3, "Freshwater" www.grida.no/geo/geo3/

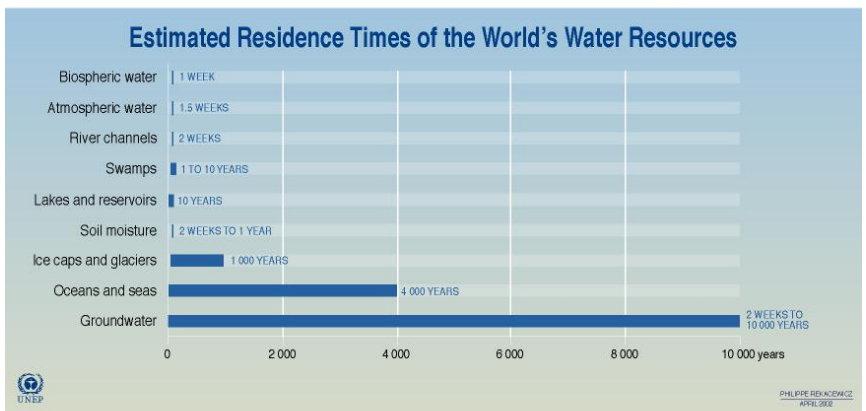

Water Is Available
But Not To Everywhere, To Everyone, And At All Times

Water Is Infinitely Renewable

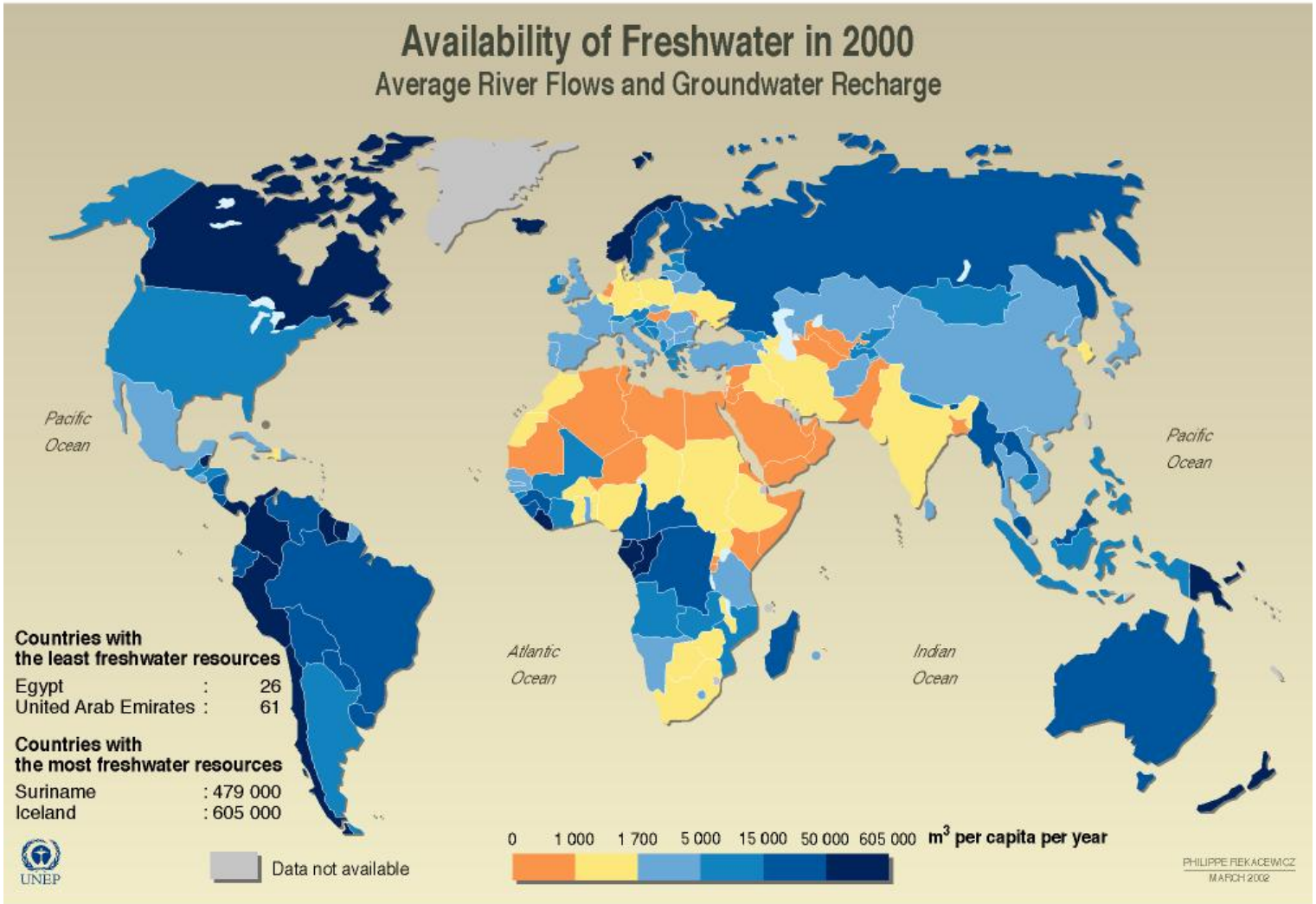
We are still using the water the dinosaurs drank.







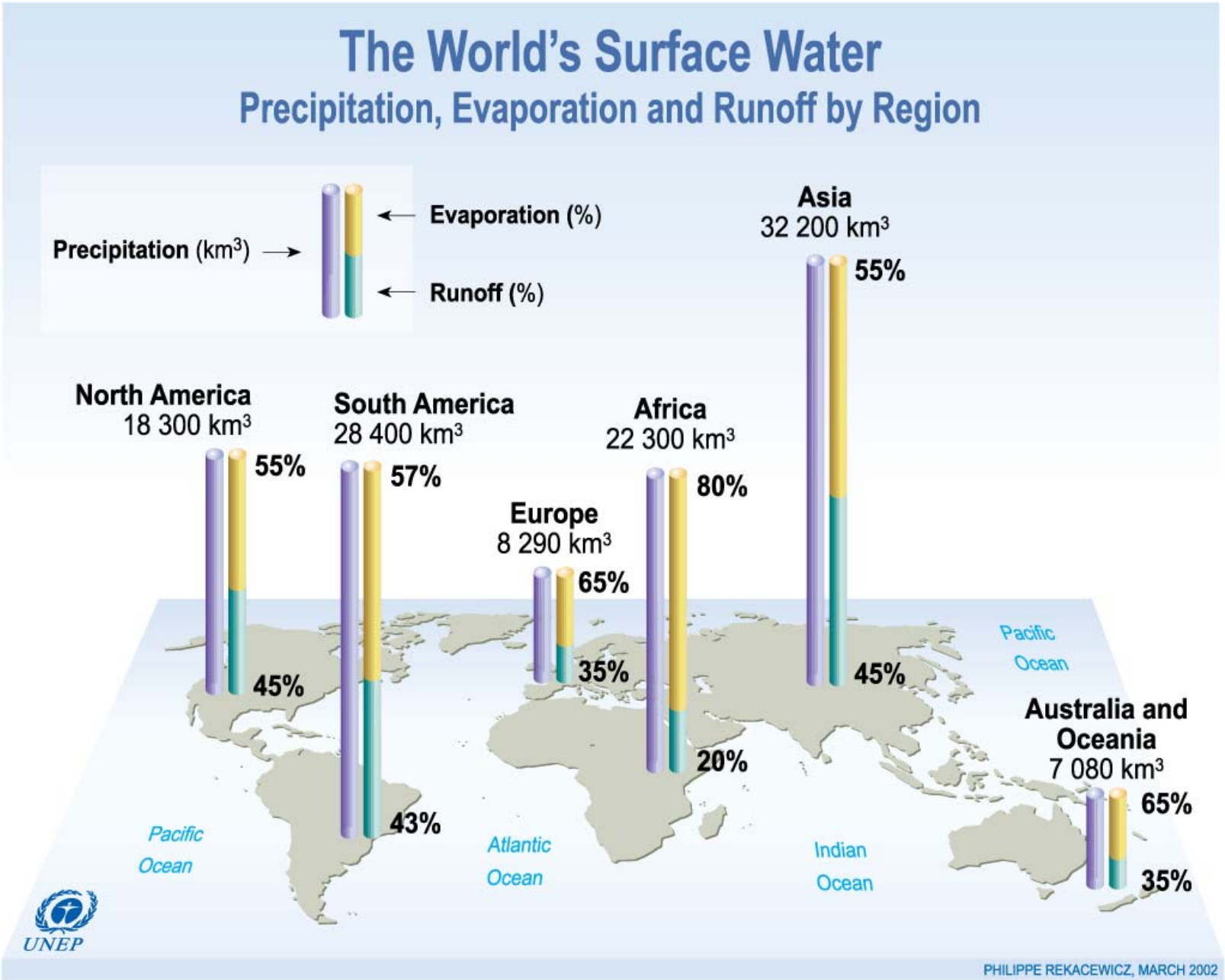
Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999; Max Planck, Institute for Meteorology, Hamburg, 1994; Freeze, Allen, John, Cherry, *Groundwater*, Prentice-Hall: Engle wood Cliffs NJ, 1979.



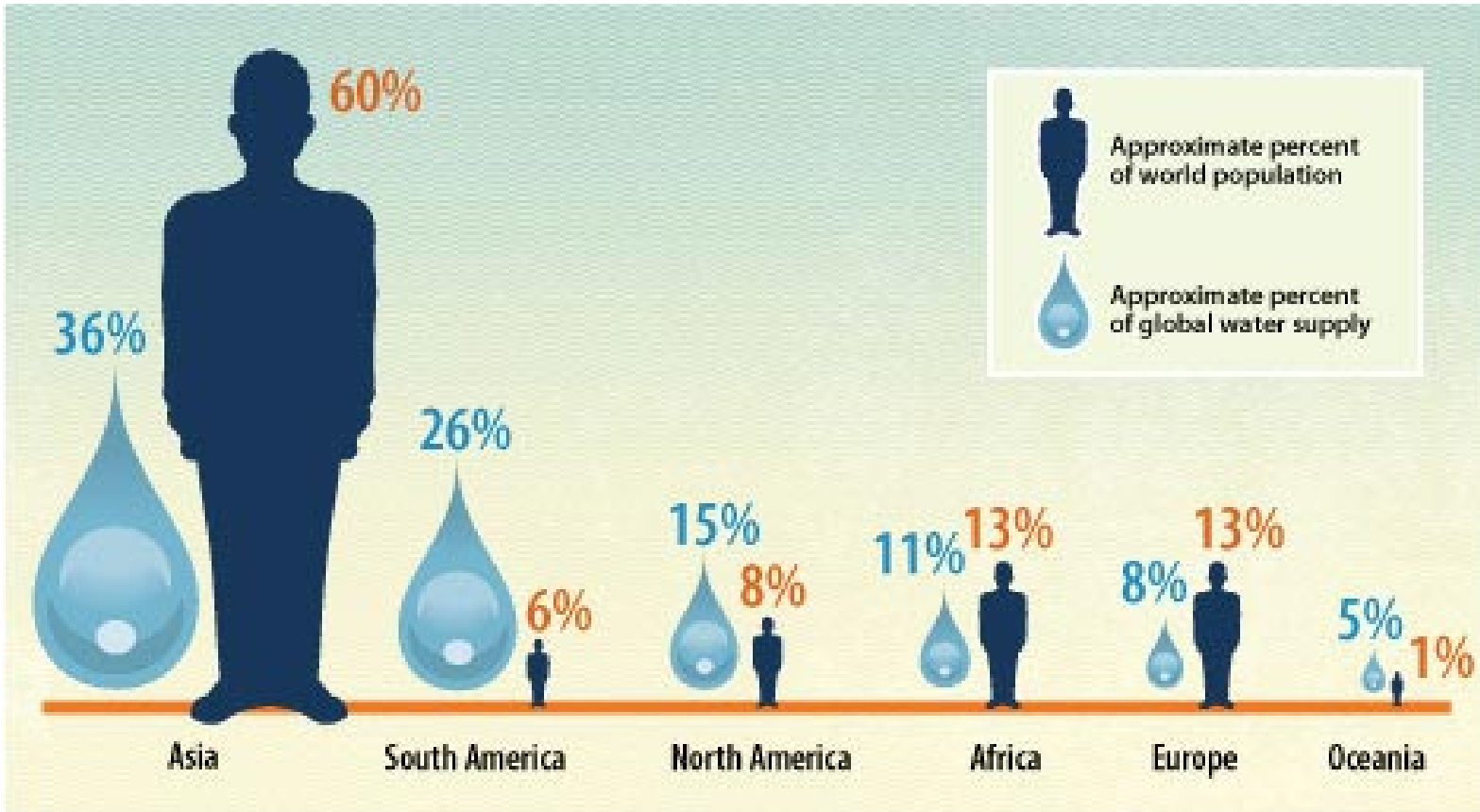
Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.

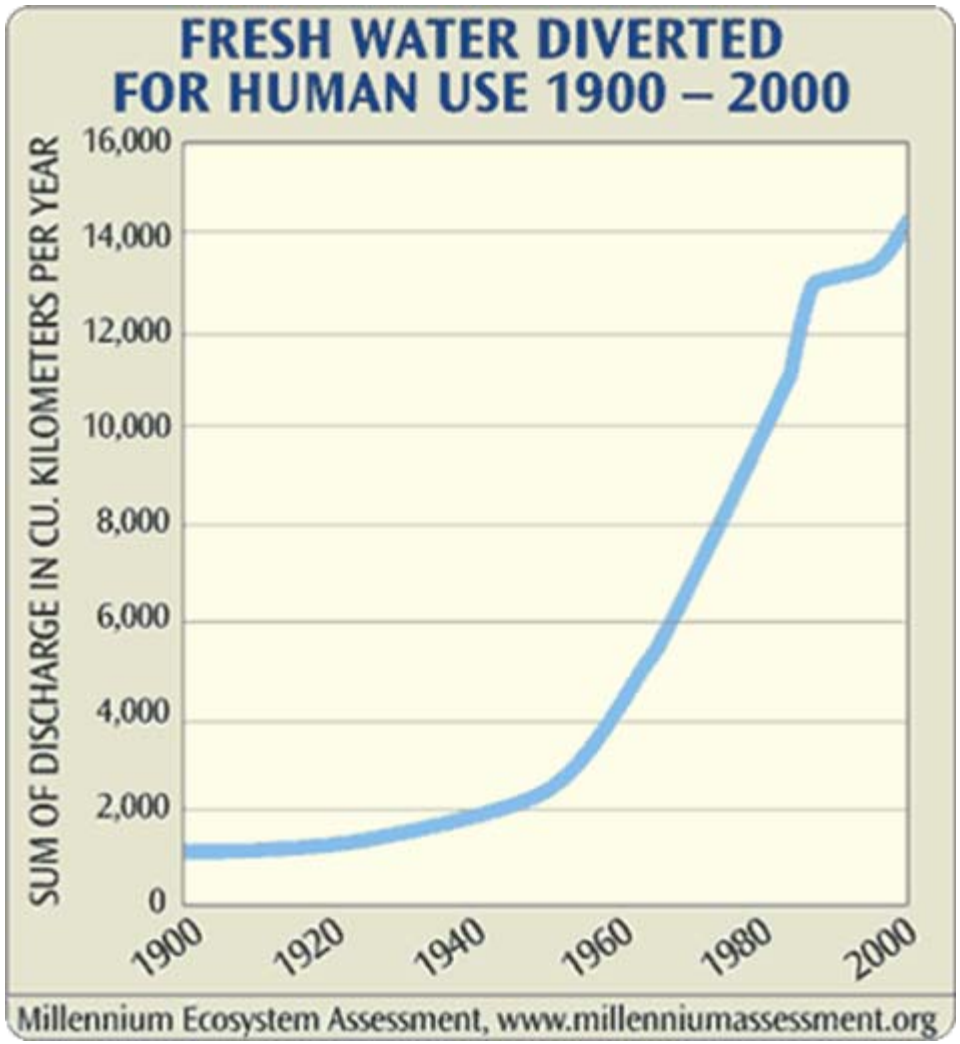
The World's Surface Water

Precipitation, Evaporation and Runoff by Region



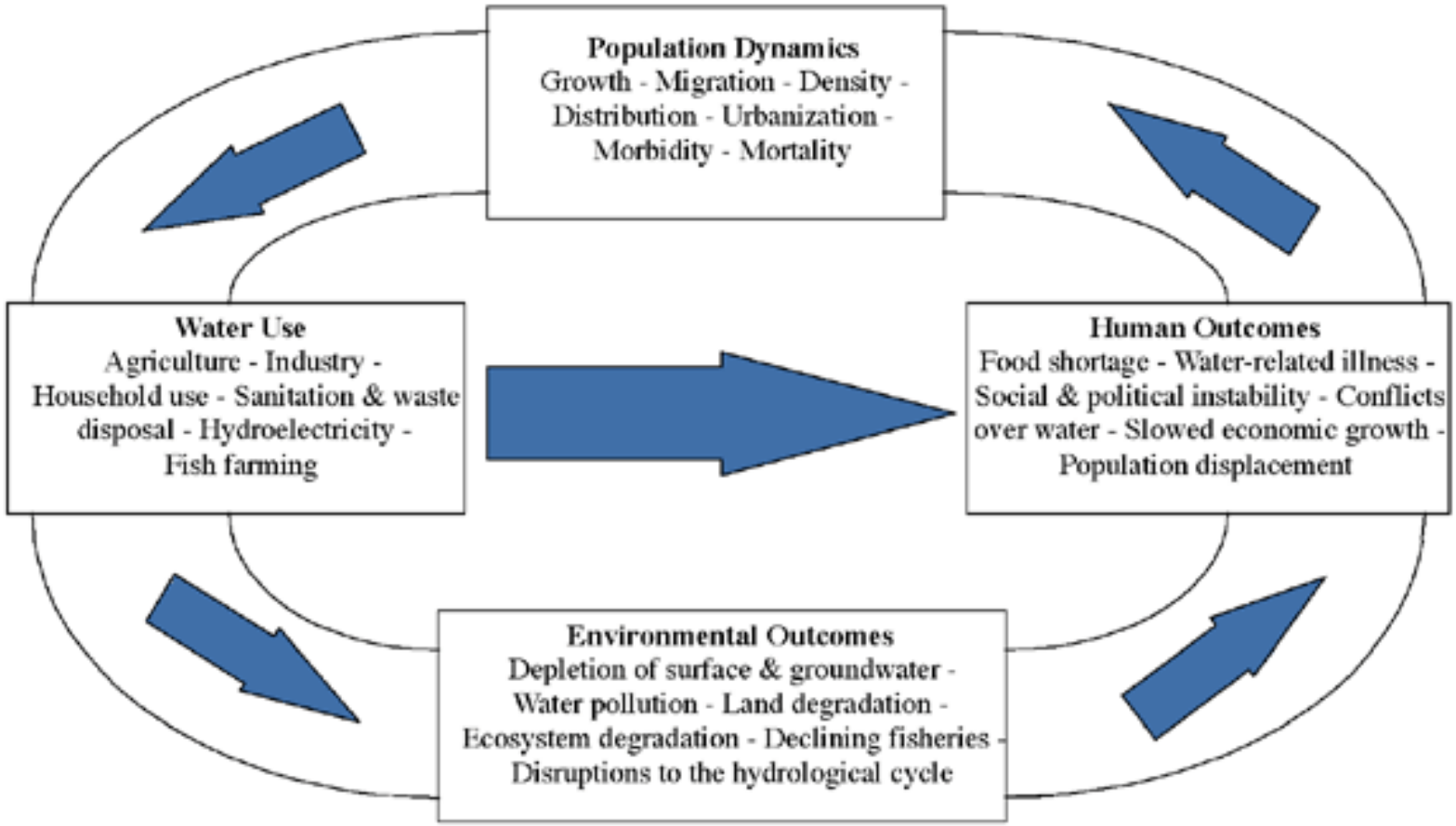
Source: Peter H. Gleick, *Water in Crisis*, New York Oxford University Press, 1993.


Approximate percent of world population
Approximate percent of global water supply
60%
36%
26%
6%
15%
8%
11%
13%
8%
13%
5%
1%
Asia
South America
North America
Africa
Europe
Oceania


FRESH WATER DIVERTED
FOR HUMAN USE 1900 – 2000
SUM OF DISCHARGE IN CU. KILOMETERS PER YEAR
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1900
1920
1940
1960
1980
2000
Millennium Ecosystem Assessment, www.millenniumassessment.org


Population Trends
and the
Demand for Water

Figure 1. Links Between Population and Freshwater



Source: IUCN et al. 1996 (199)

The turning of the water screw

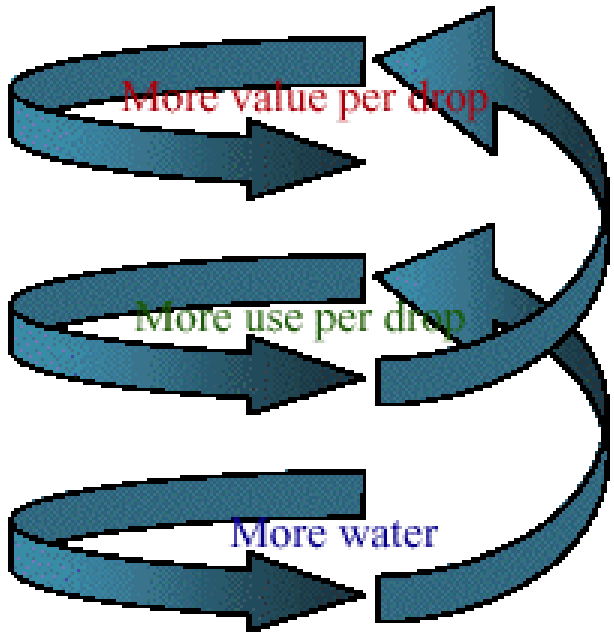
Management phase:

Management content:

•Demand management II

•Demand management I

•Supply management

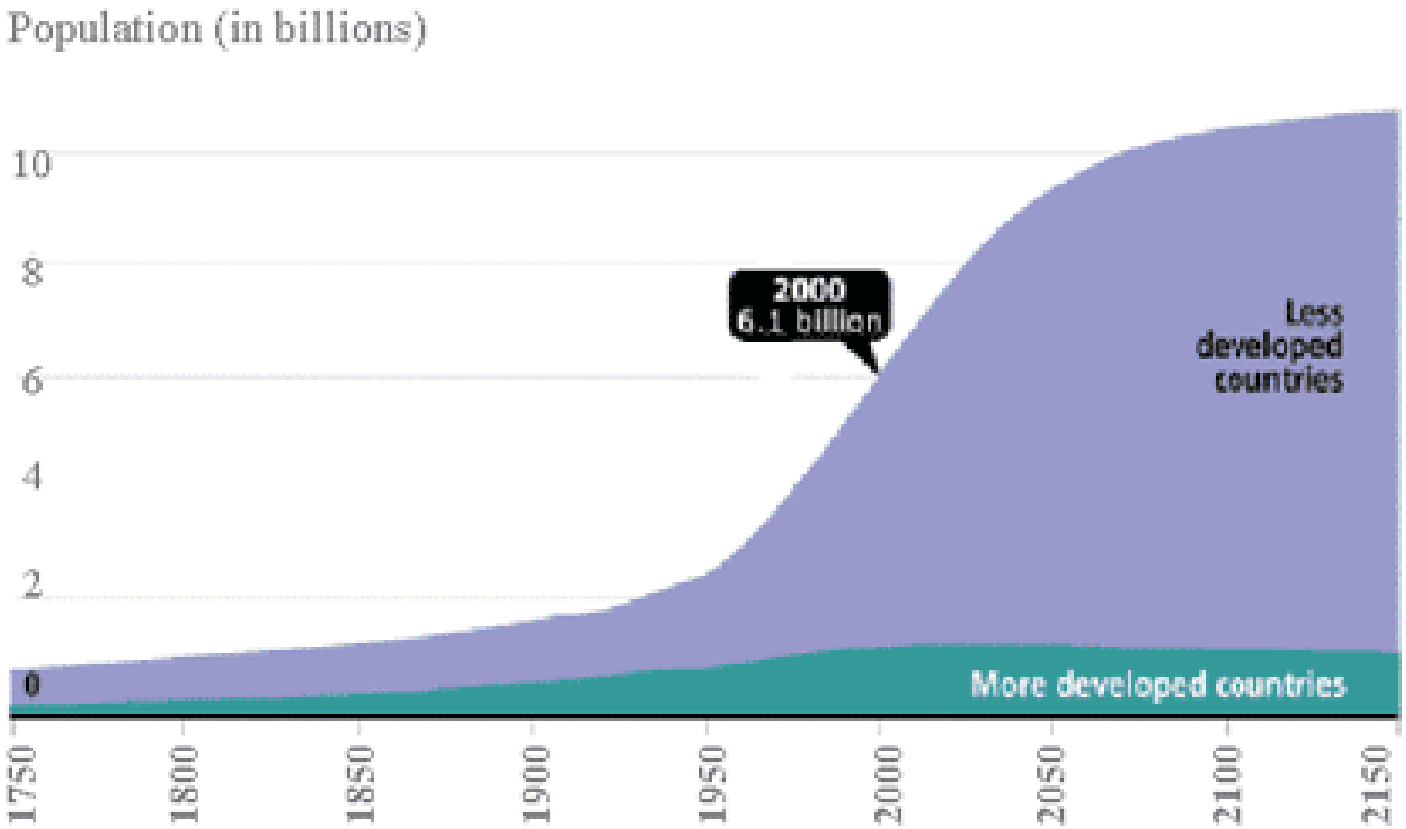


•Allocative efficiency

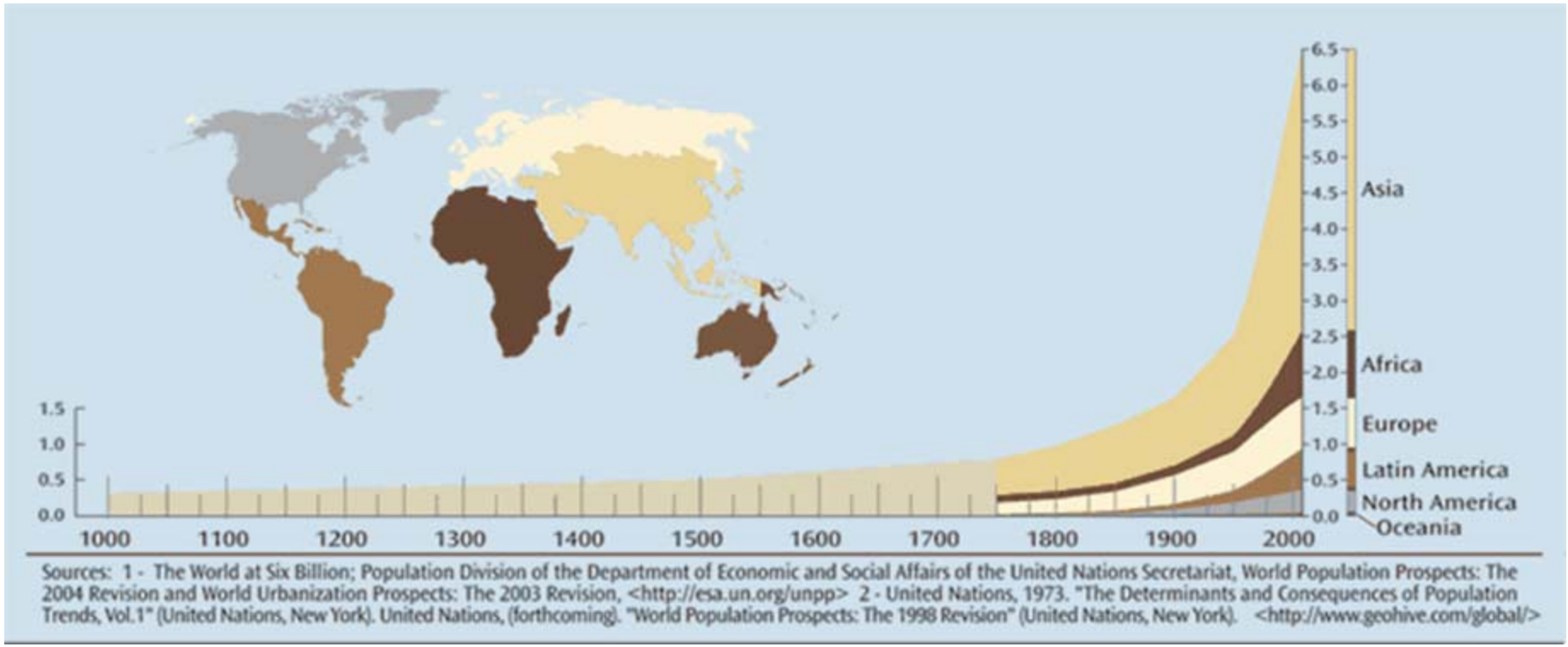
•End-use efficiency

•Engineering efforts

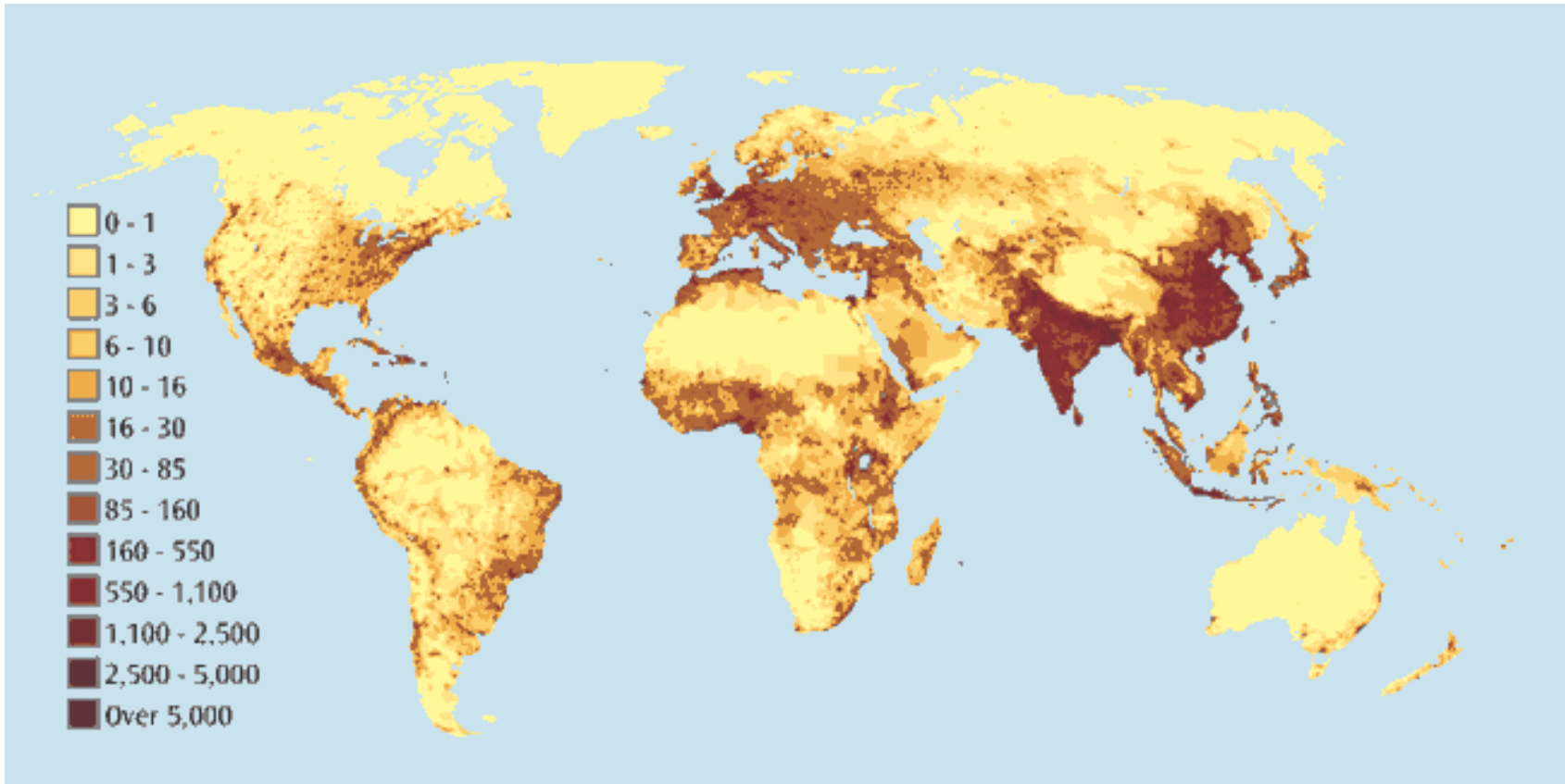
World Population Growth 1750–2150



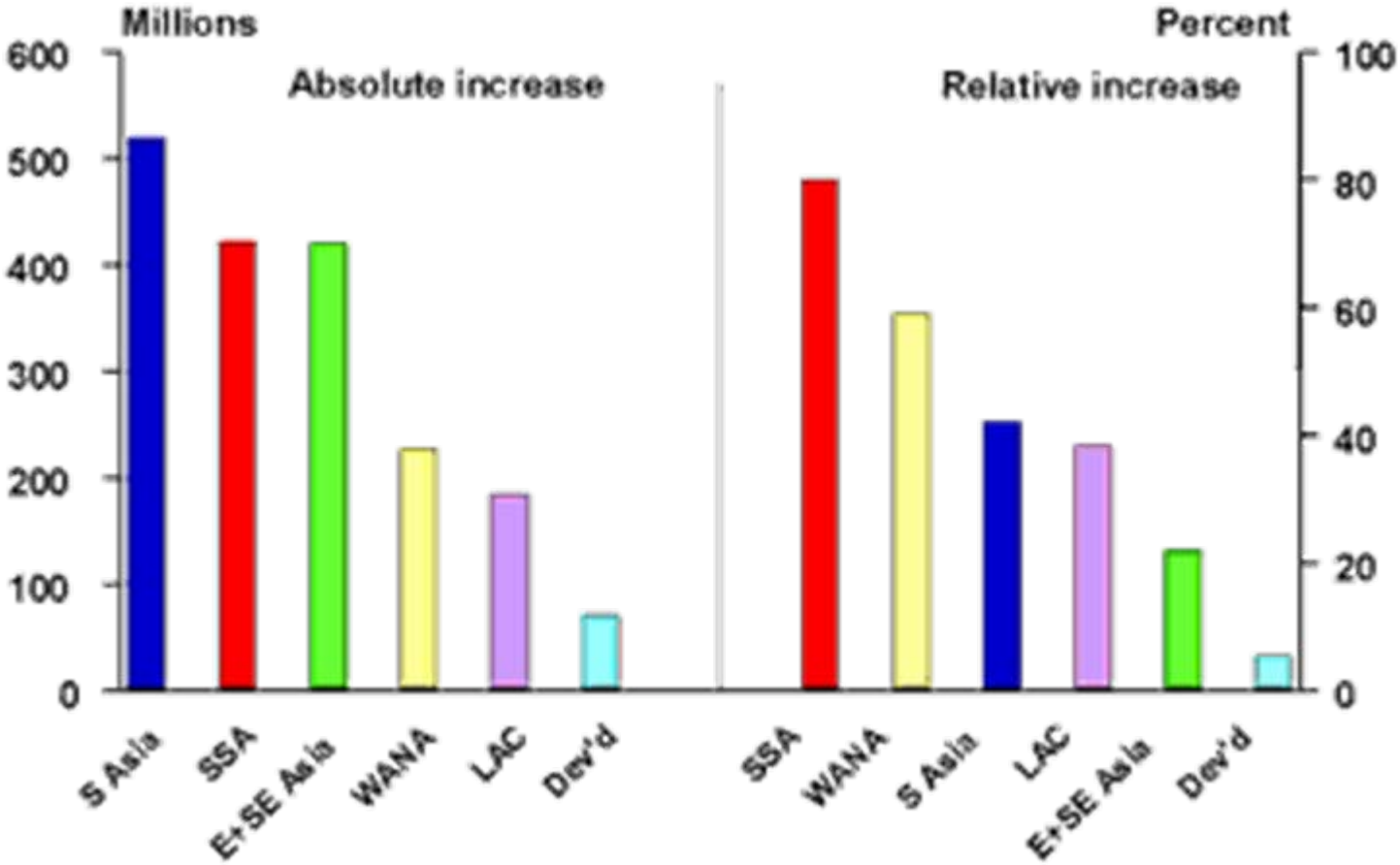
Source: United Nations, *World Population Prospects, The 1998 Revision*; and estimates by the Population Reference Bureau



Sources: 1 - The World at Six Billion; Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2004 Revision and World Urbanization Prospects: The 2003 Revision, <http://esa.un.org/unpp> 2 - United Nations, 1973. "The Determinants and Consequences of Population Trends, Vol.1" (United Nations, New York). United Nations, (forthcoming). "World Population Prospects: The 1998 Revision" (United Nations, New York). <http://www.geohive.com/global/>

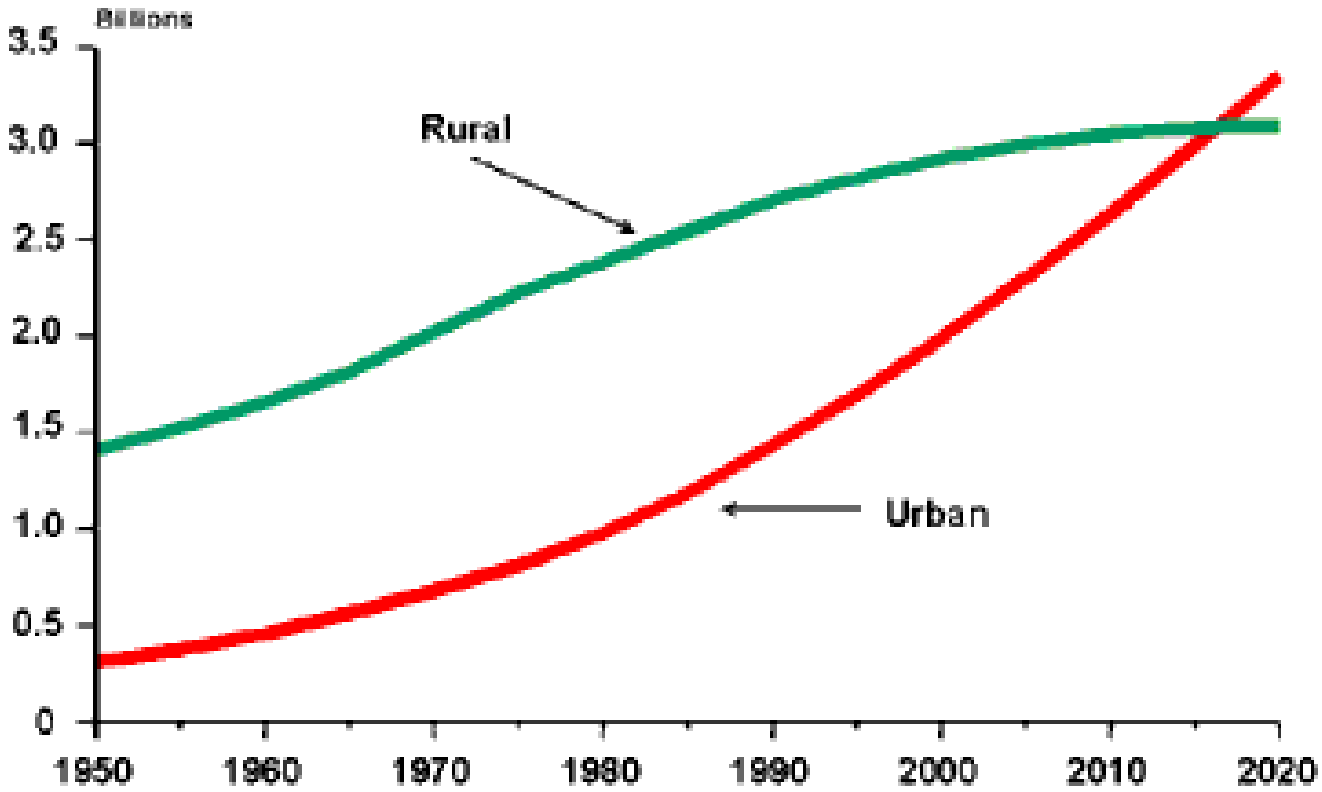

0 - 1
1 - 3
3 - 6
6 - 10
10 - 16
16 - 30
30 - 85
85 - 160
160 - 550
550 - 1,100
1,100 - 2,500
2,500 - 5,000
Over 5,000

World population increases, 1995–2020



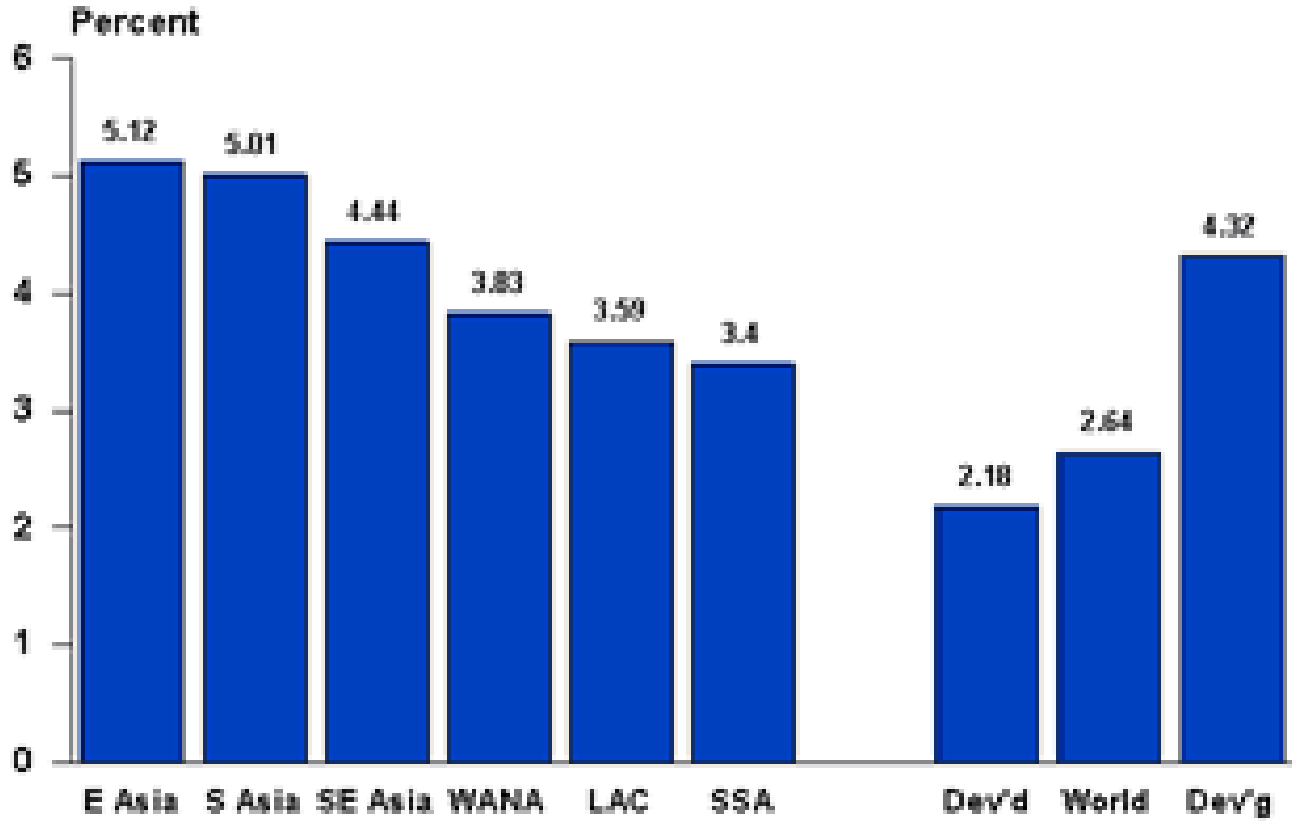
Source: Updated from P. Pinstrup-Andersen, R. Pandya-Lorch, and M.W. Rosegrant, *The World Food Situation: Recent Developments, Emerging Issues, and Long-Term Prospects* (Washington, D.C.: IFPRI, 1997).

Urban and rural population in developing countries, 1950–2020



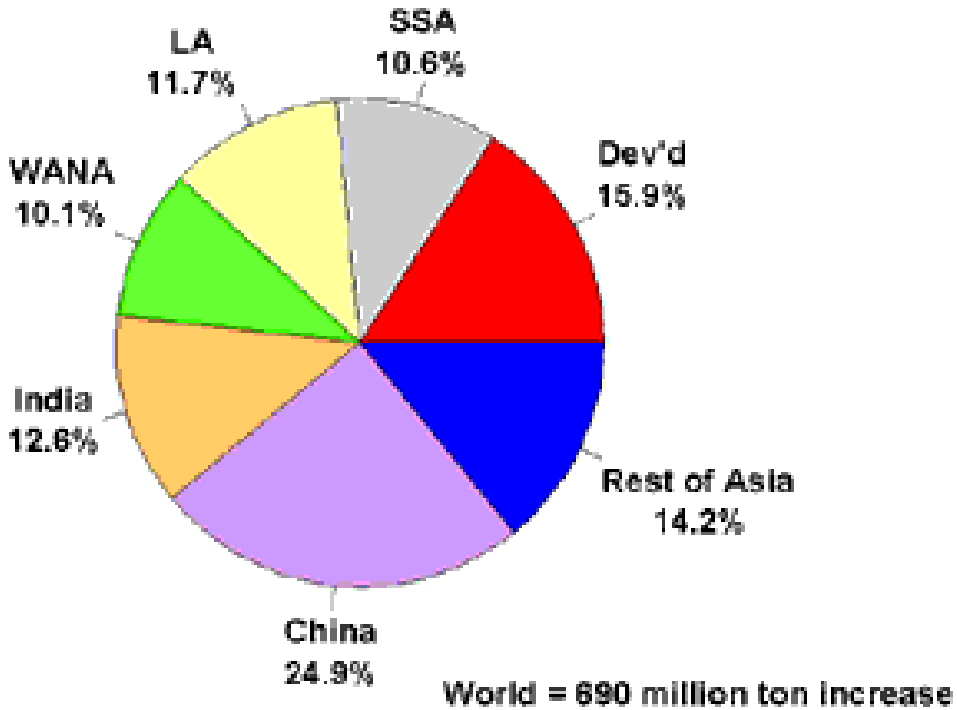
Source: P. Pinstrup-Andersen, R. Pandya-Lorch, and M.W. Rosegrant, *World Food Prospects: Critical Issues for the Early Twenty-First Century* (Washington, D.C.: IFPRI, 1999).

Projected annual income growth rates, 1995–2020



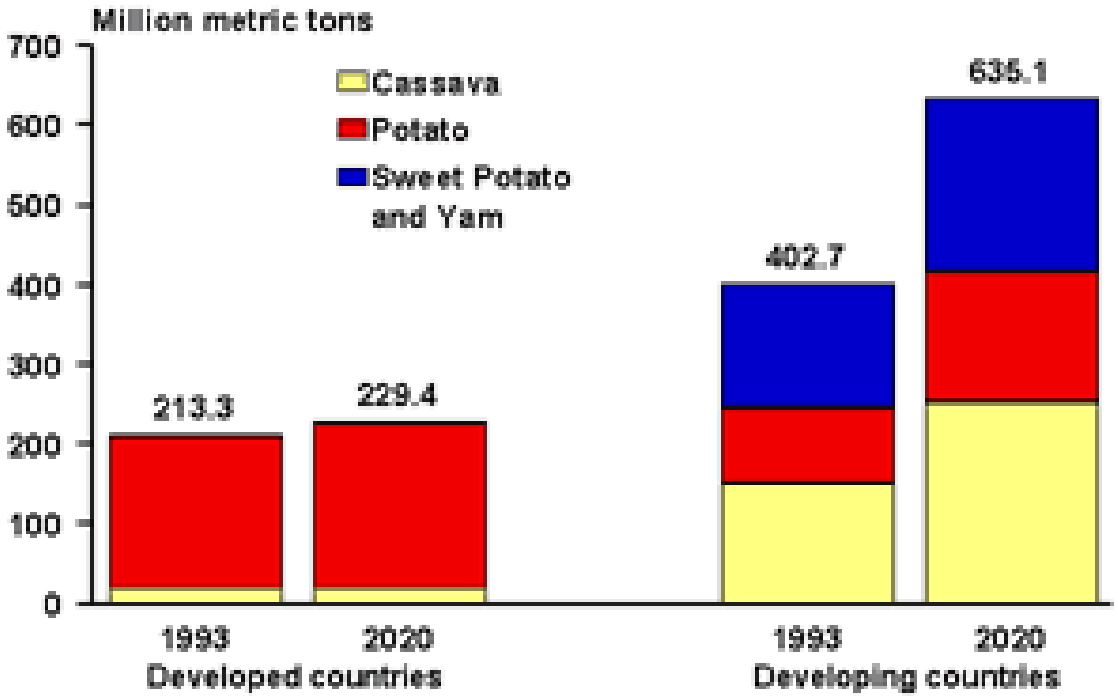
Source: Updated from P. Pinstrup-Andersen, R. Pandya-Lorch, and M.W. Rosegrant, *World Food Prospects: Critical Issues for the Early Twenty-First Century* (Washington, D.C.: IFPRI, 1999).

Share of increase in global demand for cereals, 1995–2020



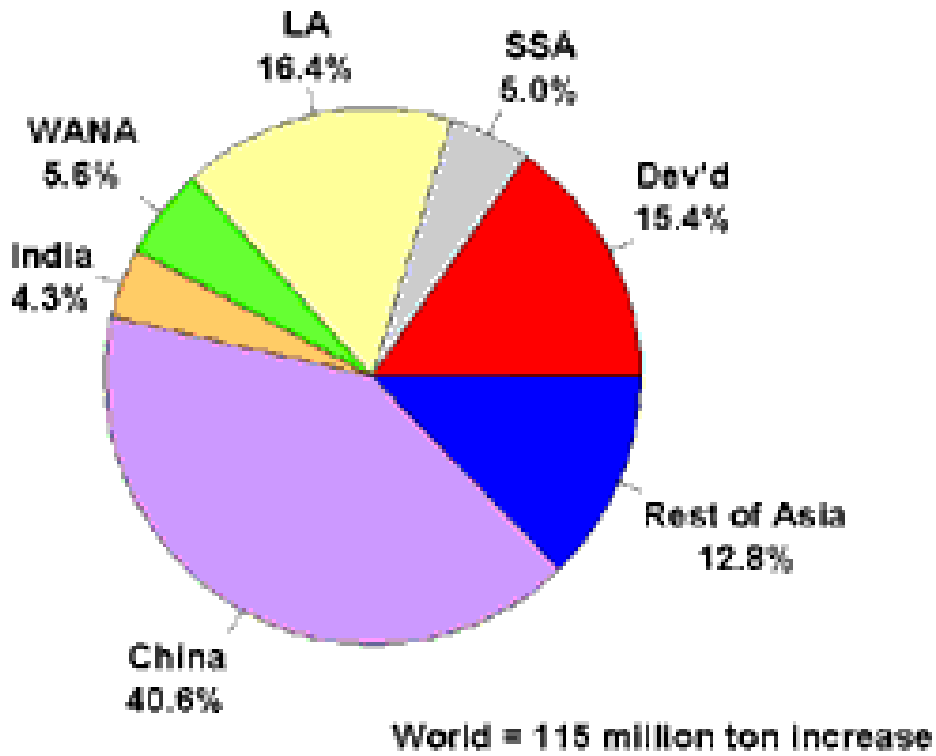
Source: P. Pinstrup-Andersen, R. Pandya-Lorch, and MW. Rosegrant, *World Food Prospects: Critical Issues for the Early Twenty-First Century* (Washington, D.C.: IFPRI, 1999).

Total demand for roots and tubers by commodity, 1993-2020



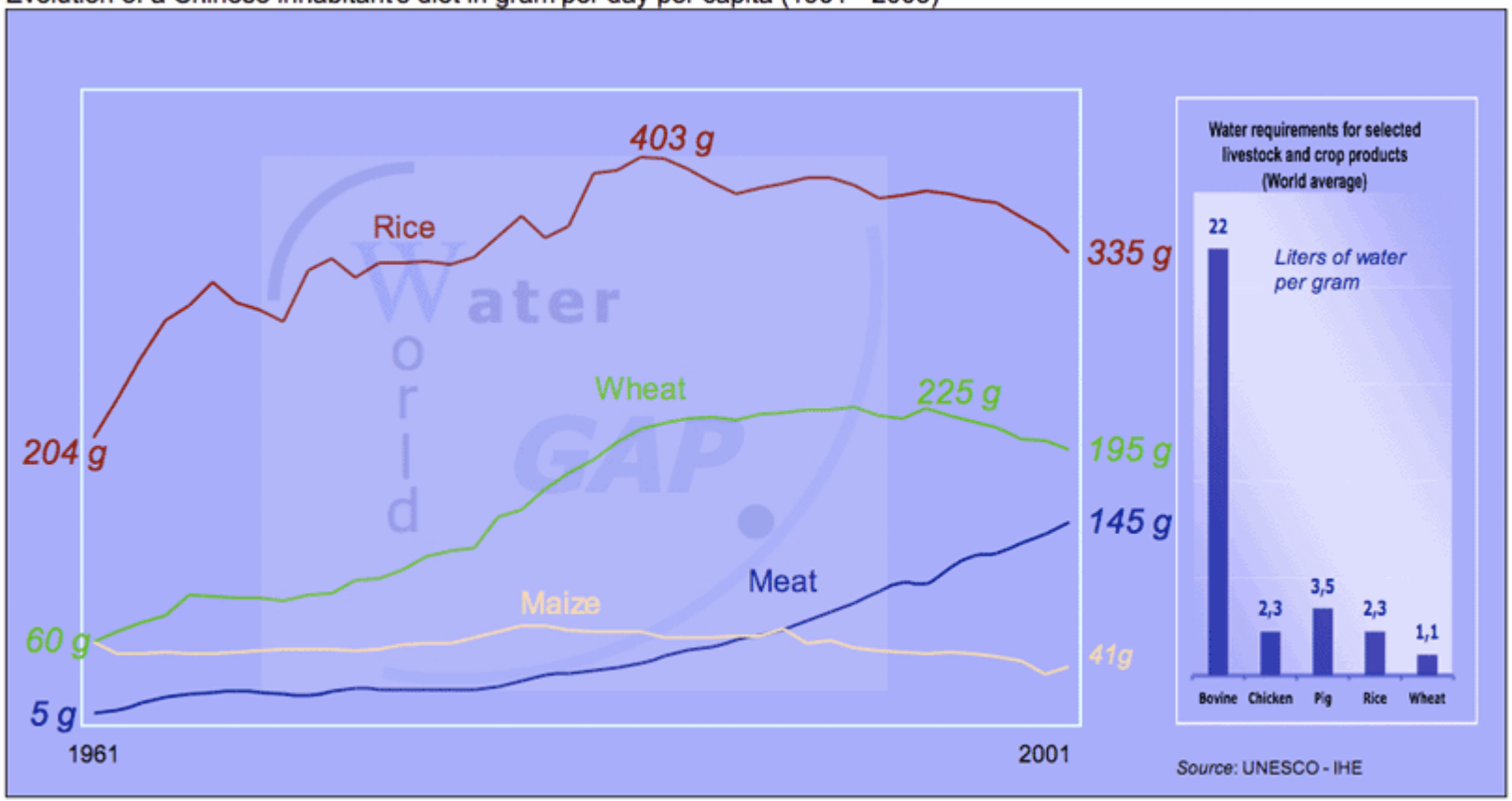
Source: G.J. Scott, M.W. Rosegrant, and C. Ringler. *Roots and tubers for the 21st century: Trends, projections, and policy options* (Washington, DC: IFPRI, 2000).

Share of increase in global demand for meat products, 1995–2020

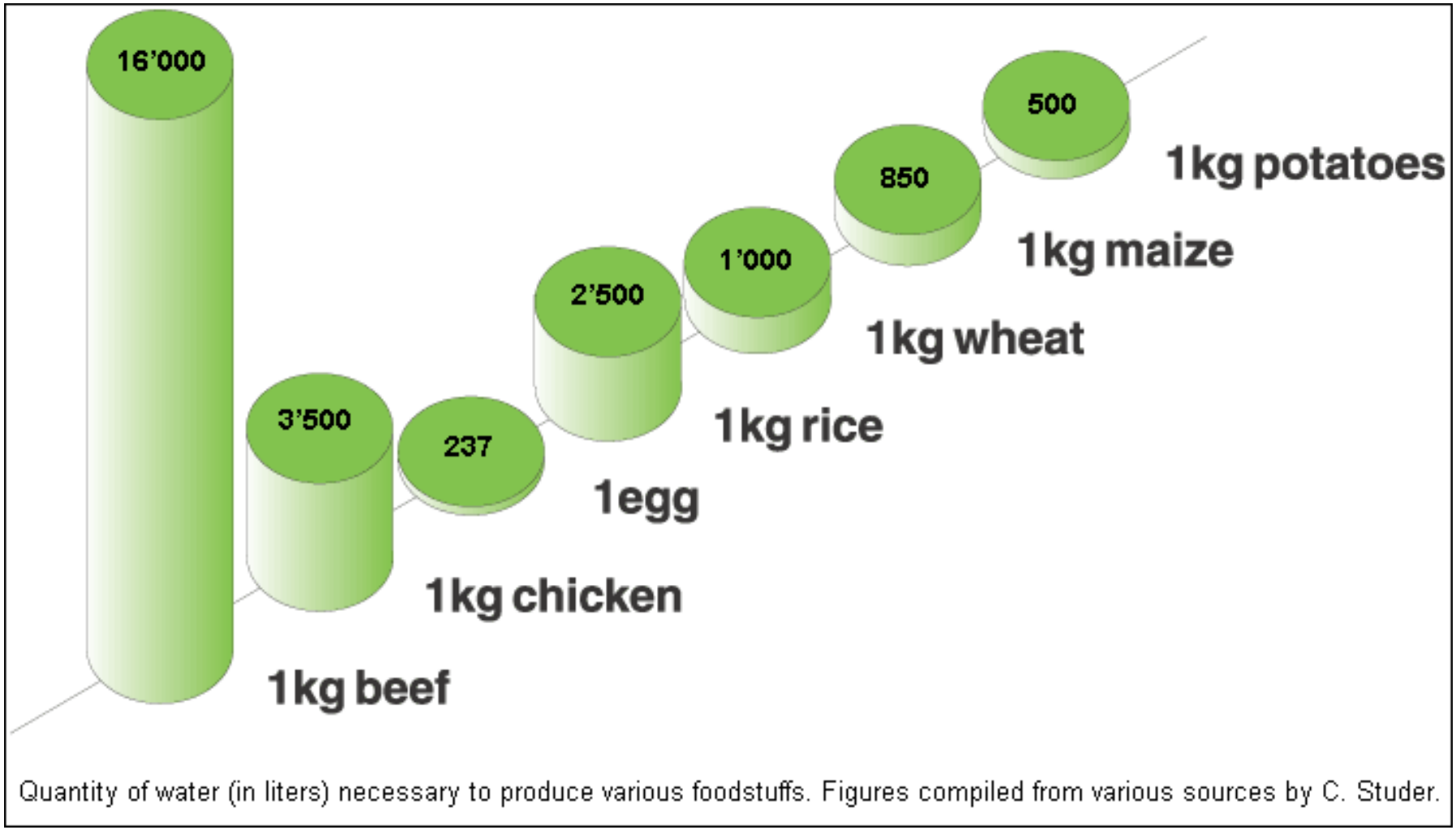


Source: P. Pinstrup-Andersen, R. Pandya-Lorch, and M.W. Rosegrant, *World Food Prospects: Critical Issues for the Early Twenty-First Century* (Washington, D.C.: IFPRI, 1999).

Evolution of a Chinese inhabitant's diet in gram per day per capita (1961 - 2003)



Source: FAOSTAT, online database
Calulations: Water *GAP*



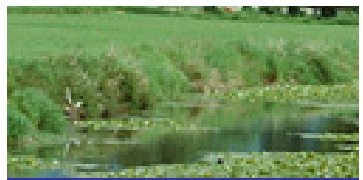
Quantity of water (in liters) necessary to produce various foodstuffs. Figures compiled from various sources by C. Studer.

15,340 CROP WATER

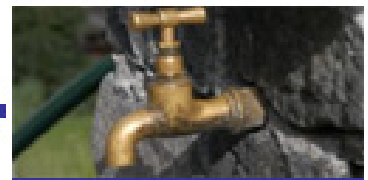
One 150 gram burger =
2400 litres of embedded water

1300kg GRAIN

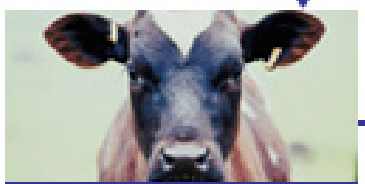
7200kg ROUGHAGES



24,000 DRINKING



7,000 SERVICING

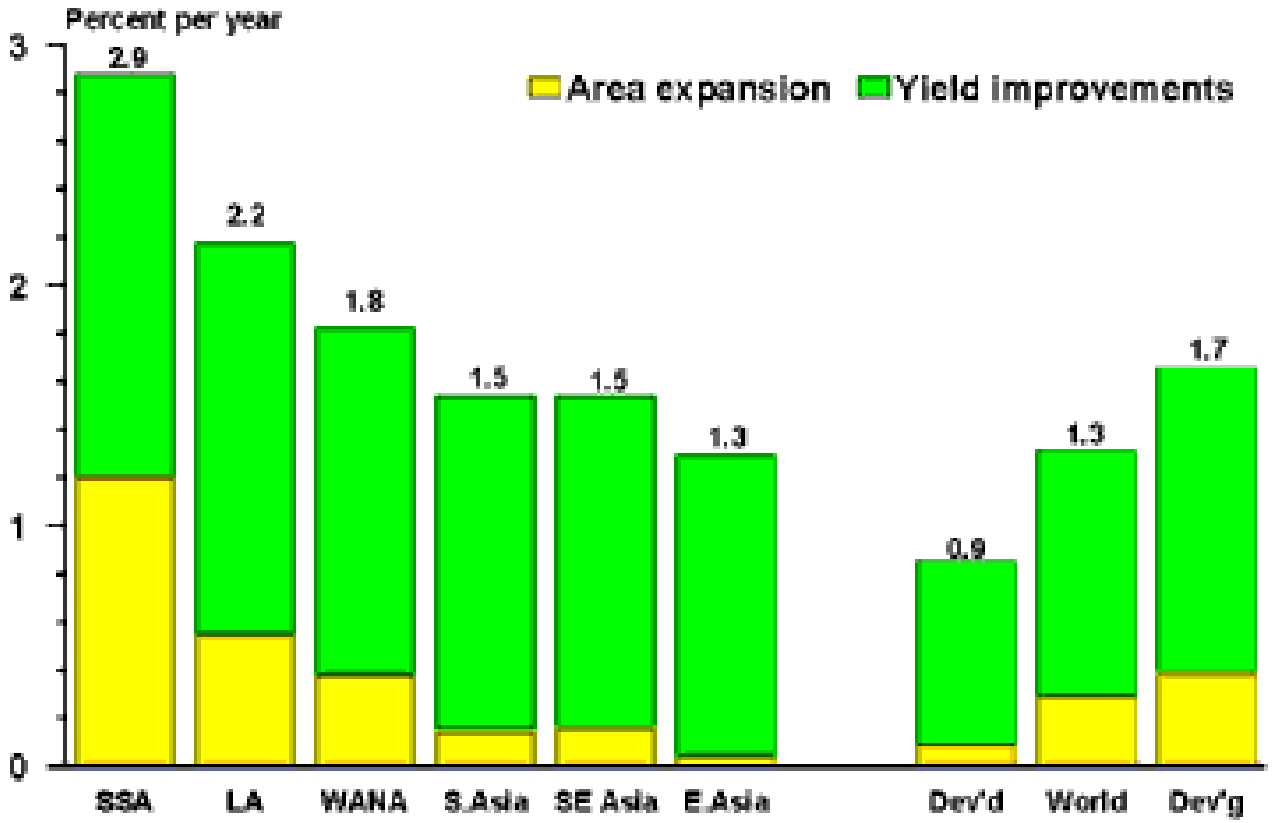


1 COW

200kg BEEF

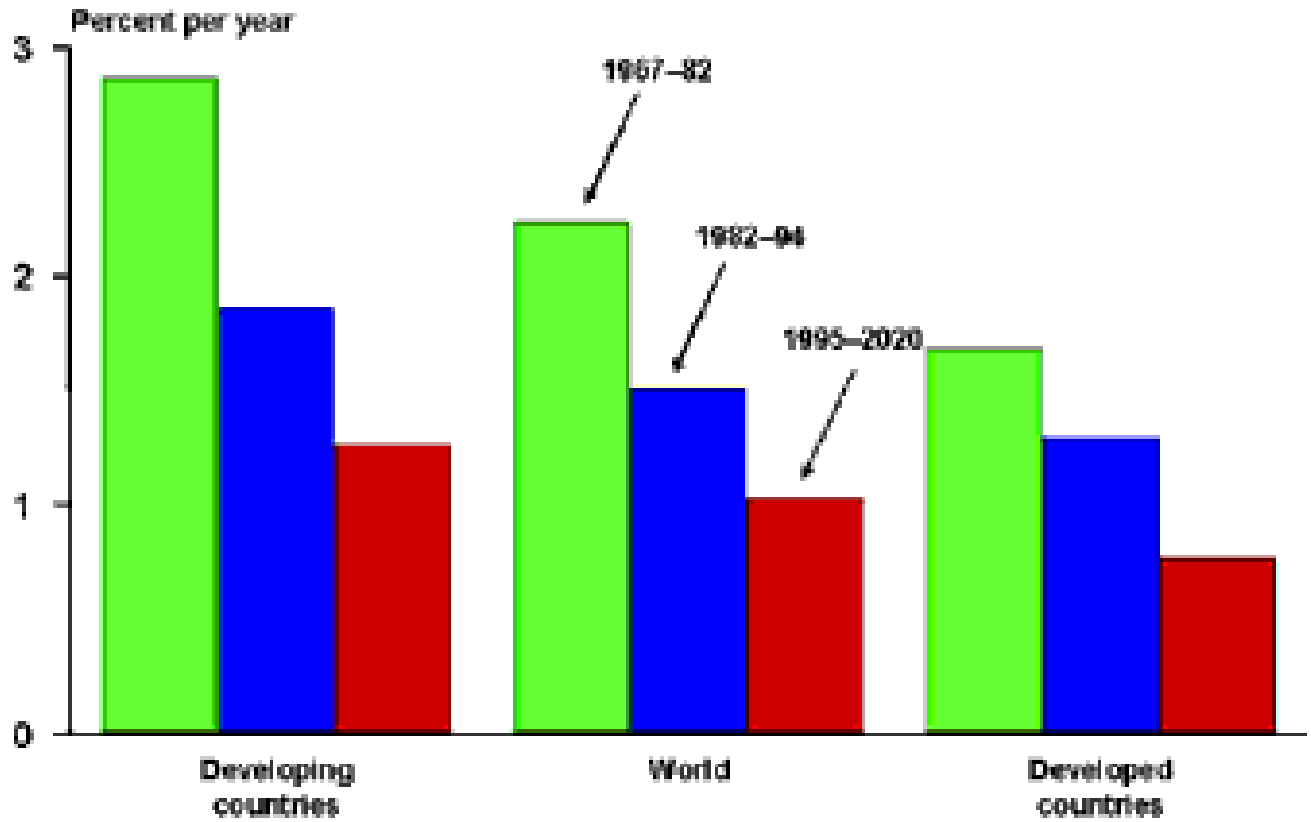
2400 in one BURGER

Sources of growth in cereal production, 1995–2020



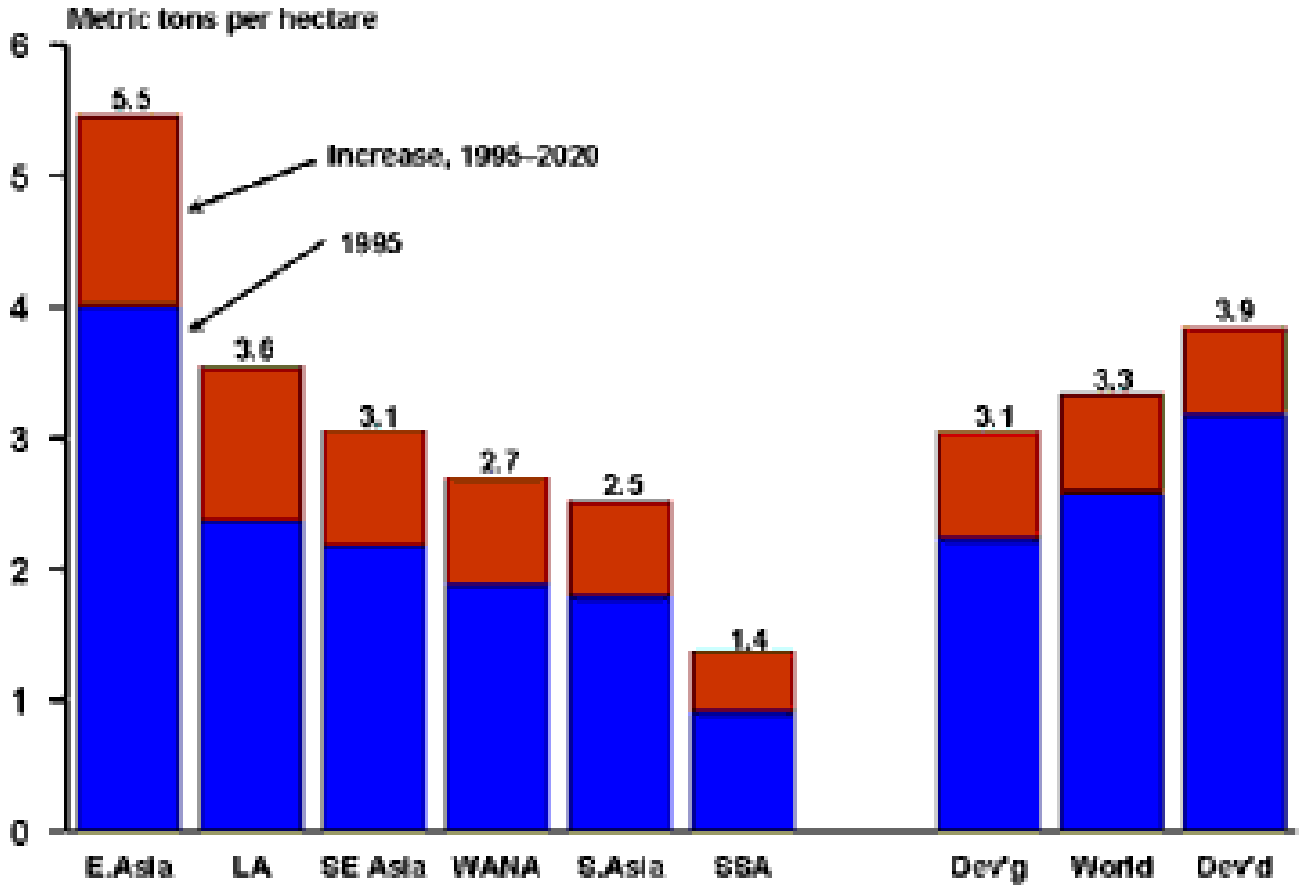
Source: P. Pinstrup-Andersen, R. Pandya-Lorch, and MW. Rosegrant, *World Food Prospects: Critical Issues for the Early Twenty-First Century* (Washington, D.C.: IFPRI, 1999).

Annual growth in cereal yields, 1967–82, 1982–94, and 1995–2020



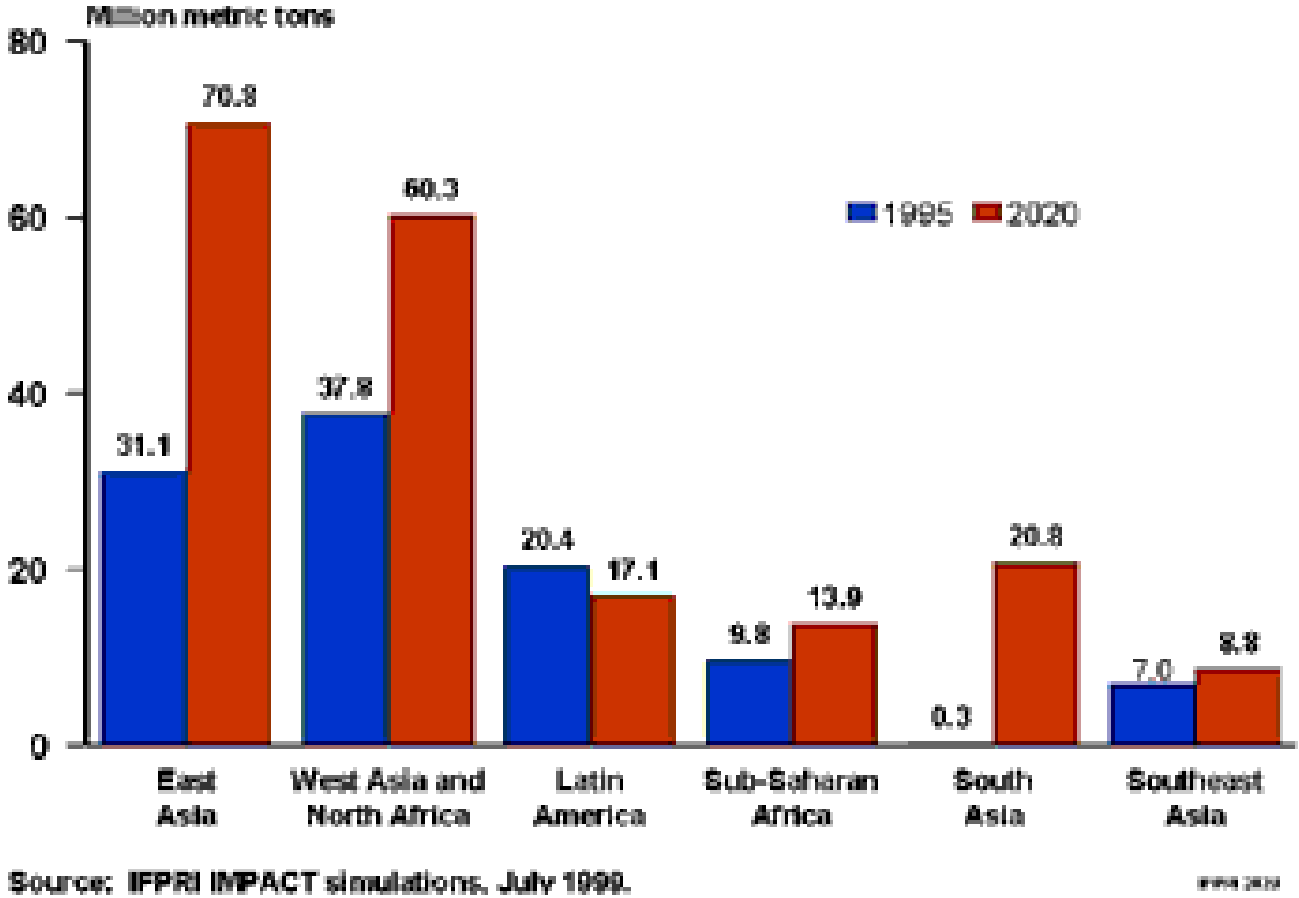
Source: P. Pinstrup-Andersen, R. Pandya-Lorch, and M.W. Rosegrant, *World Food Prospects: Critical Issues for the Early Twenty-First Century* (Washington, D.C.: IFPRI, 1999).

Cereal yields, 1995–2020



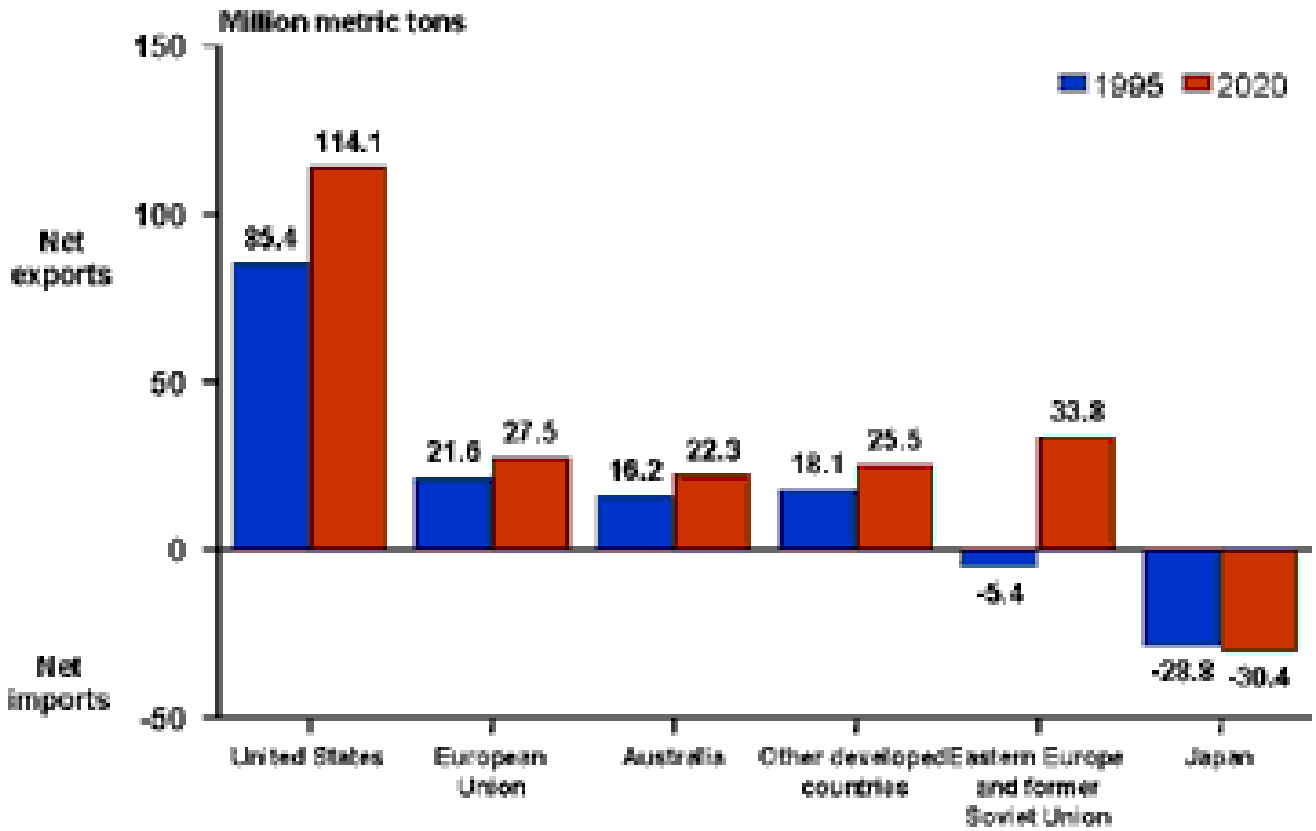
Source: P. Pinstrup-Andersen, R. Pandya-Lorch, and M.W. Rosegrant, *World Food Prospects: Critical Issues for the Early Twenty-First Century* (Washington, D.C.: IFPRI, 1999).

Net cereal imports of major developing regions, 1995 and 2020



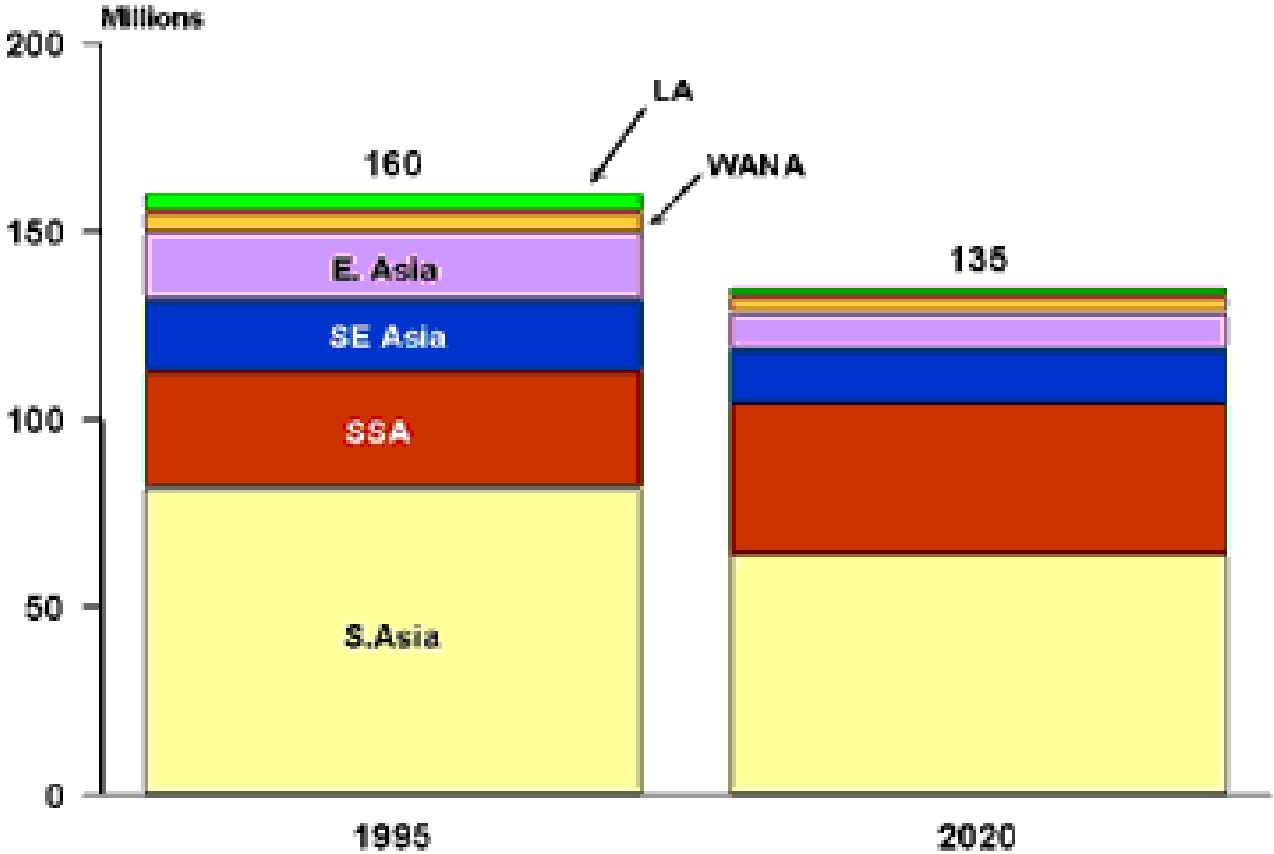
Source: IFPRI IMPACT simulations, July 1999.

Net trade in cereal of developed countries, 1995 and 2020



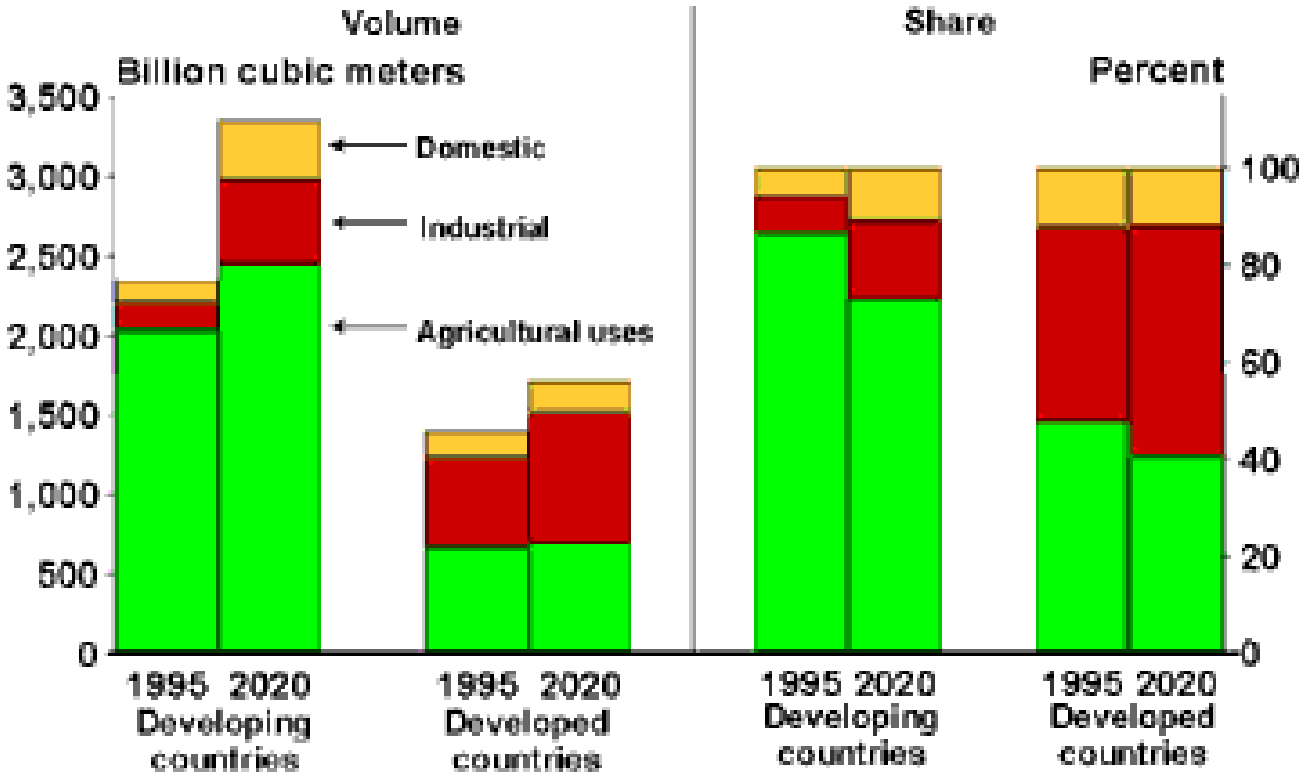
Source: IFPRI IMPACT simulations, July 1999.

Number of malnourished children, 1995 and 2020



Source: P. Pinstrup-Andersen, R. Pandya-Lorch, and M.W. Rosegrant, *World Food Prospects: Critical Issues for the Early Twenty-First Century* (Washington, D.C.: IFPRI, 1999).

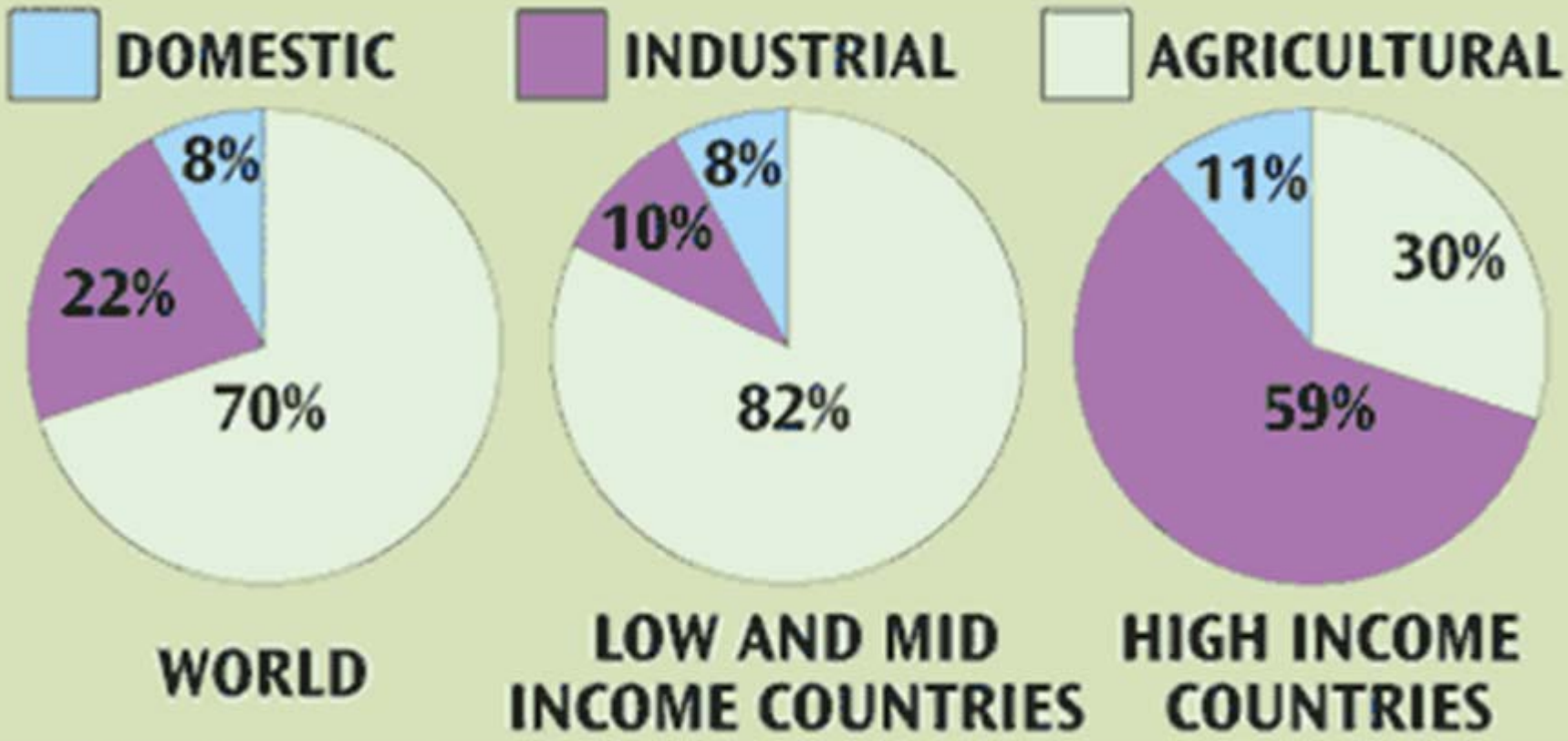
Water withdrawals for domestic, industrial, and agricultural uses, 1995 and 2020



Source: P. Pinstrup-Andersen, R. Pandya-Lorch, and M.W. Rosegrant, *The World Food Situation: Recent Developments, Emerging Issues, and Long-Term Prospects* (Washington, D.C.: IFPRI, 1997).

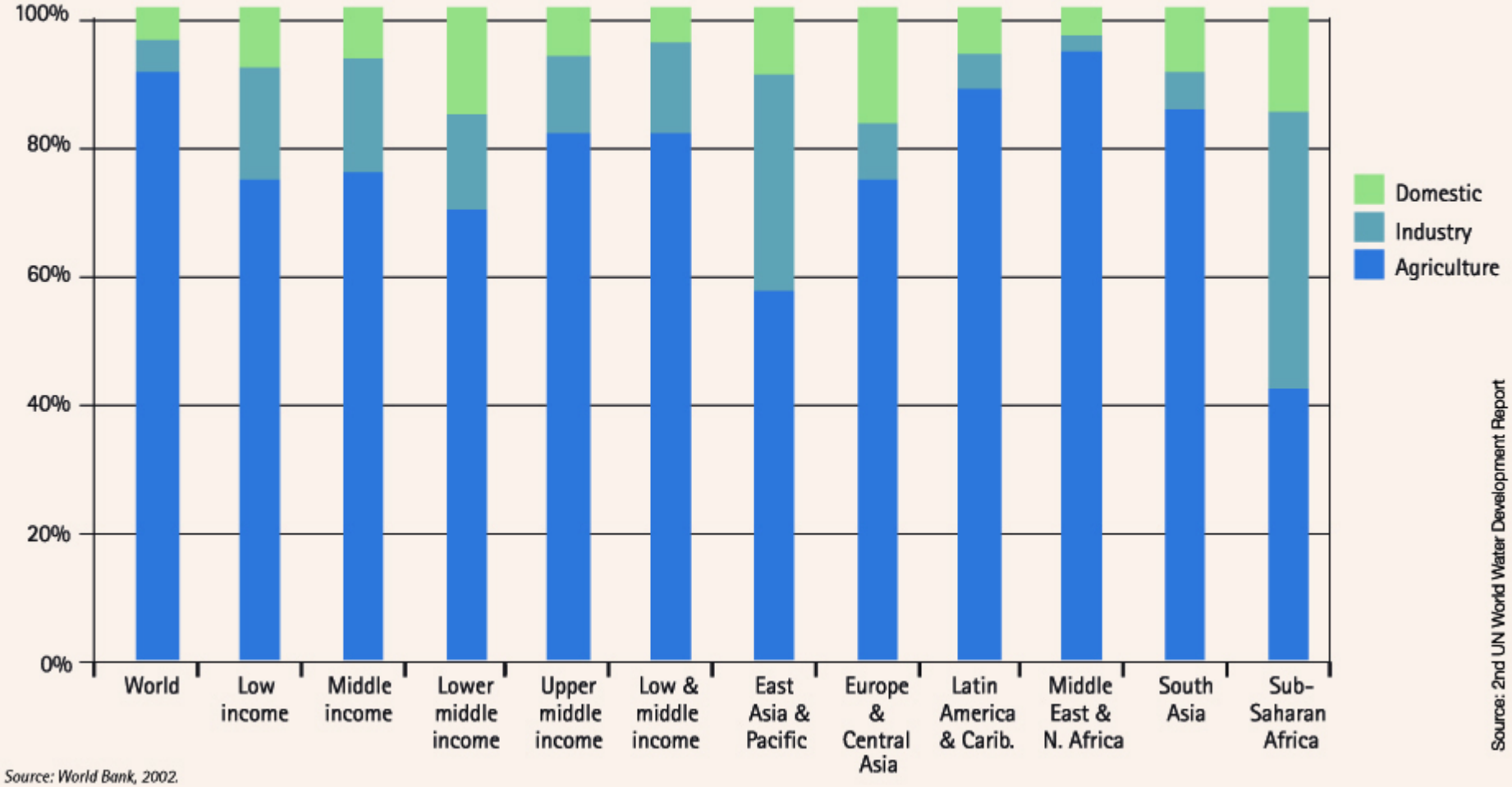
Water Use By Agriculture

COMPETING WATER USES



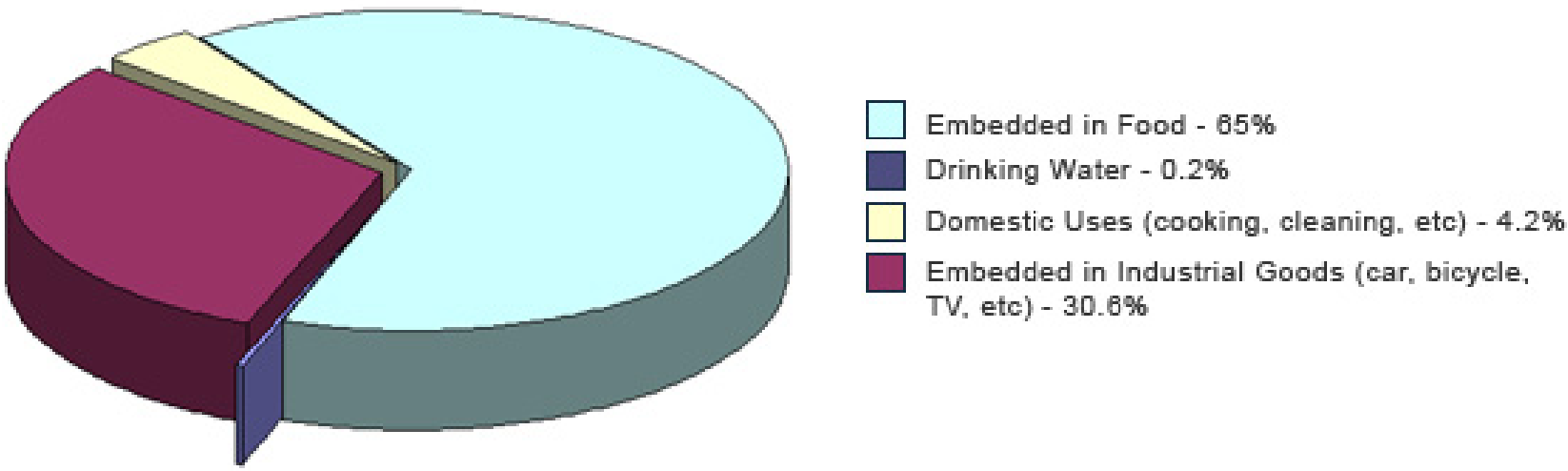
SOURCE: World Water Development Report,
www.unesco.org/water/wwap/facts_figures/water_industry.shtml

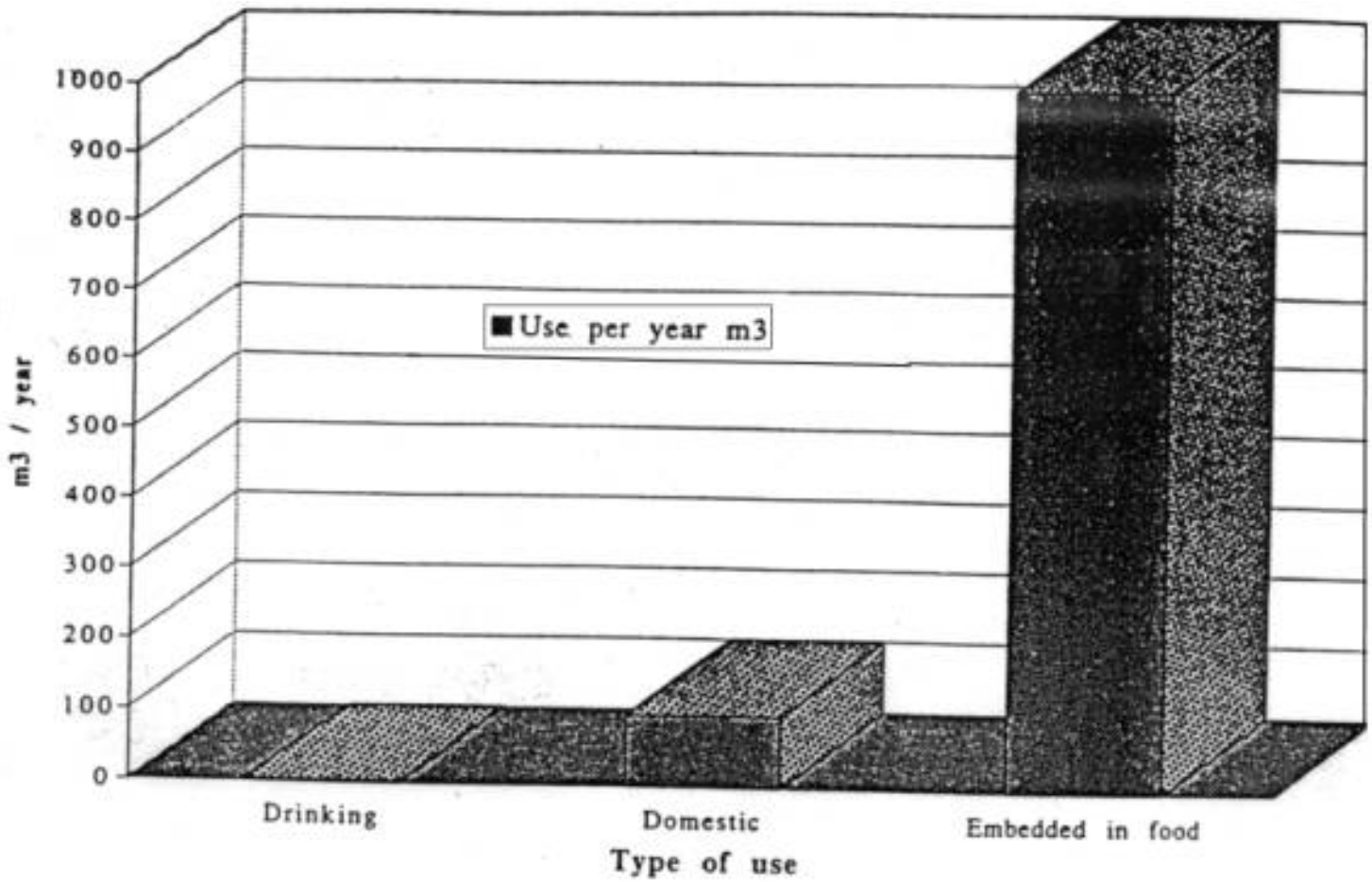
Water use by sector



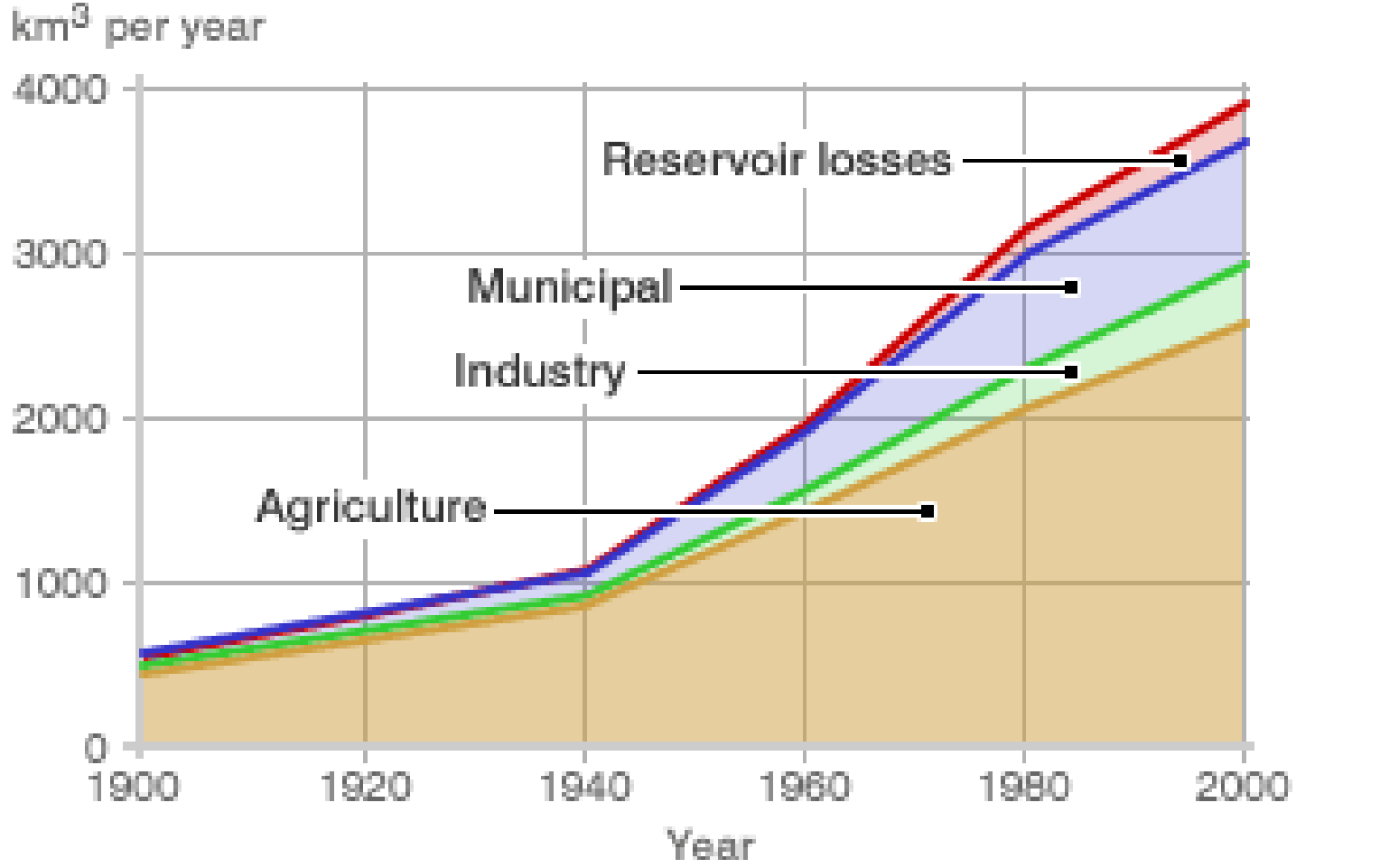
Source: 2nd UN World Water Development Report

Source: World Bank, 2002.

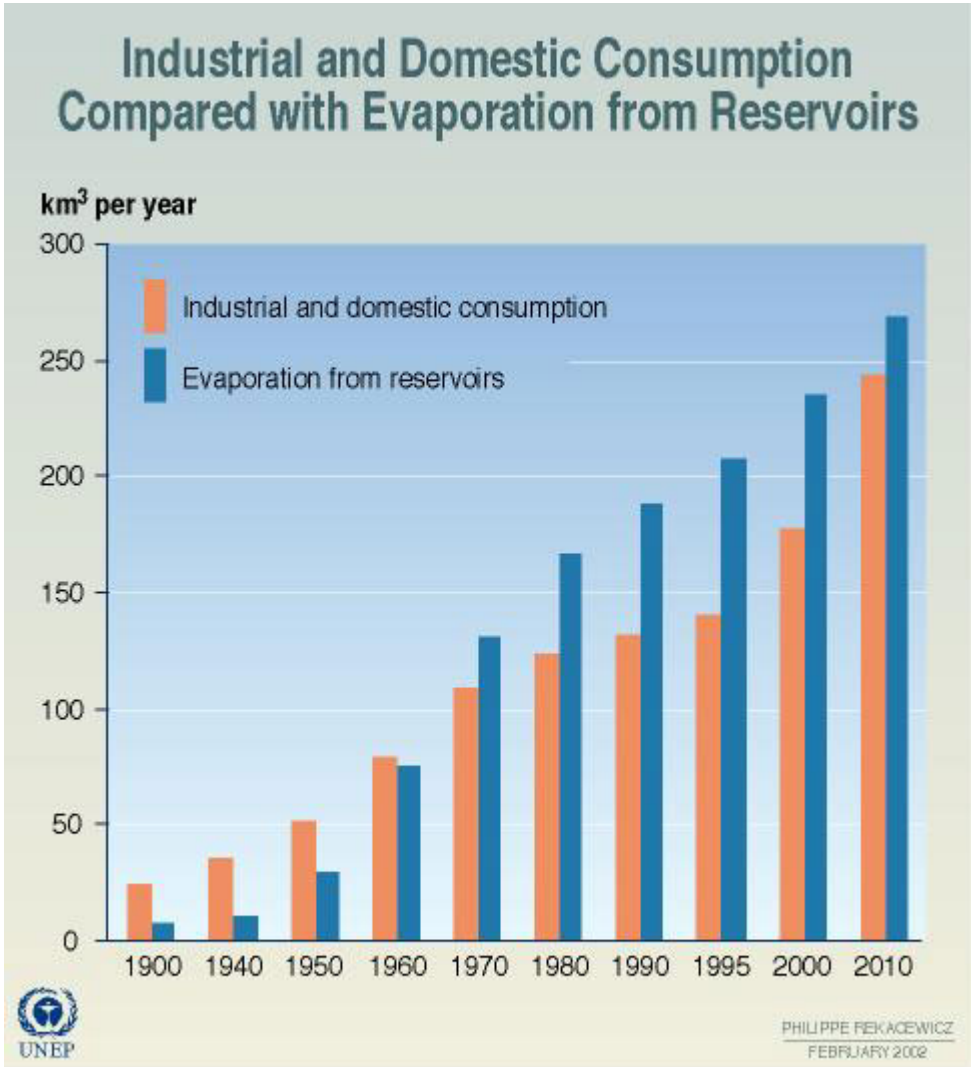

Embedded in Food - 65%
Drinking Water - 0.2%
Domestic Uses (cooking, cleaning, etc) - 4.2%
Embedded in Industrial Goods (car, bicycle, TV, etc) - 30.6%


1000
900
800
700
600
500
400
300
200
100
0
m3 / year
Use per year m3
Drinking
Domestic
Embedded in food
Type of use

Estimated annual world water use

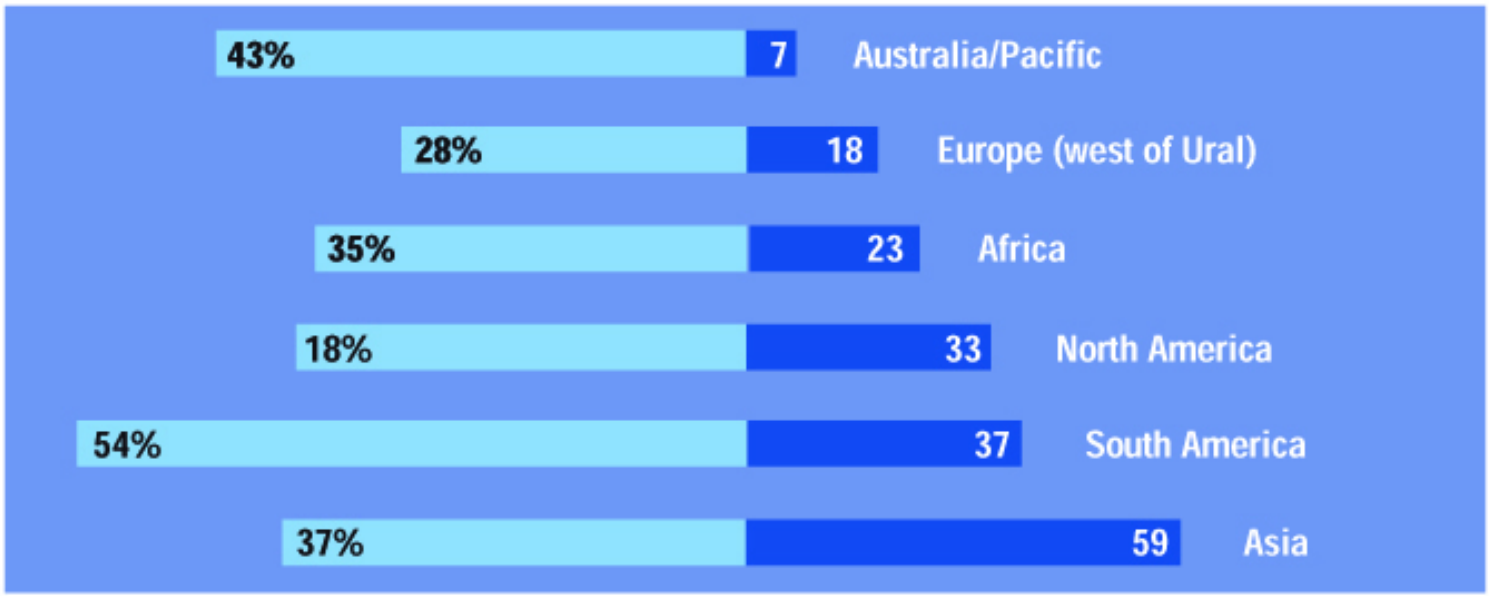


SOURCE: FAO Aquastat

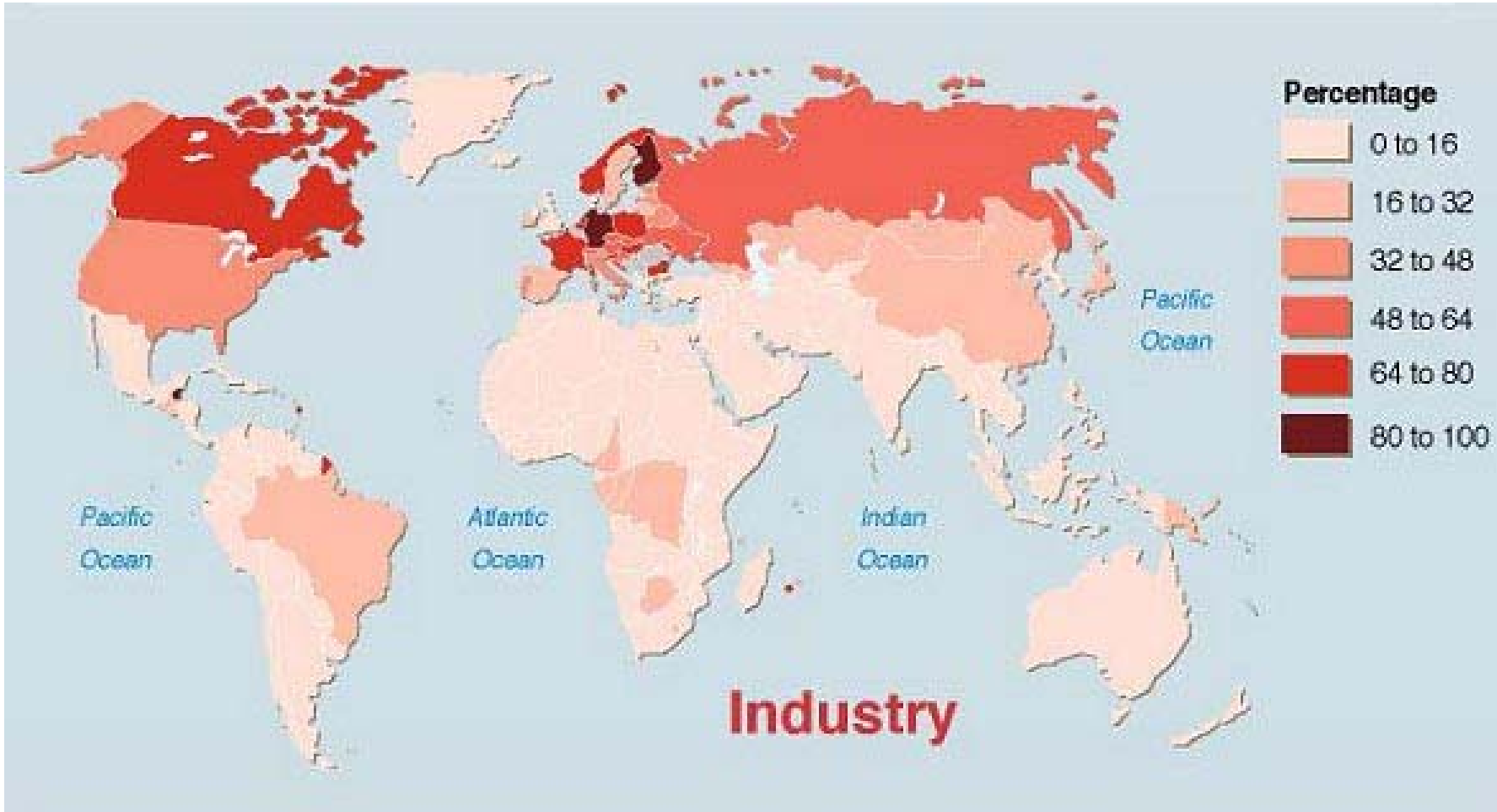


Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational,Scientific and Cultural Organisation (UNESCO, Paris), 1999.

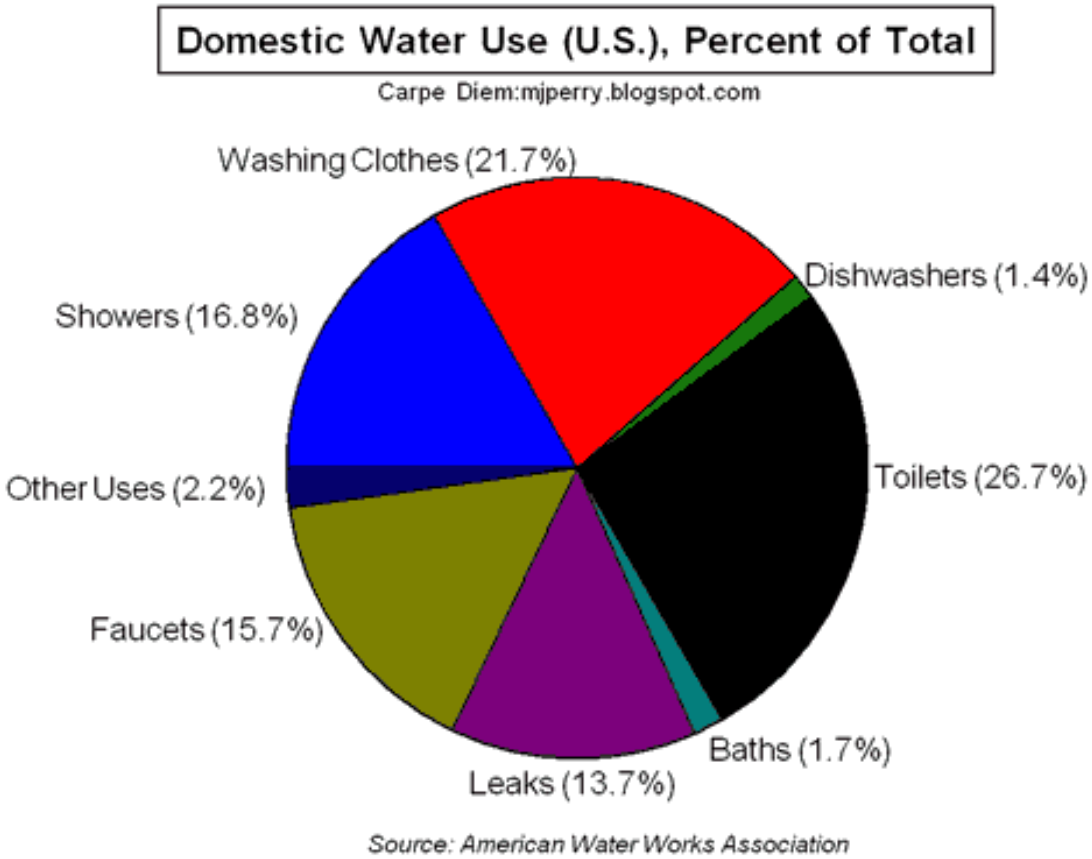
Regional distribution of rivers longer than 1,000 km and percentage of rivers remaining free-flowing

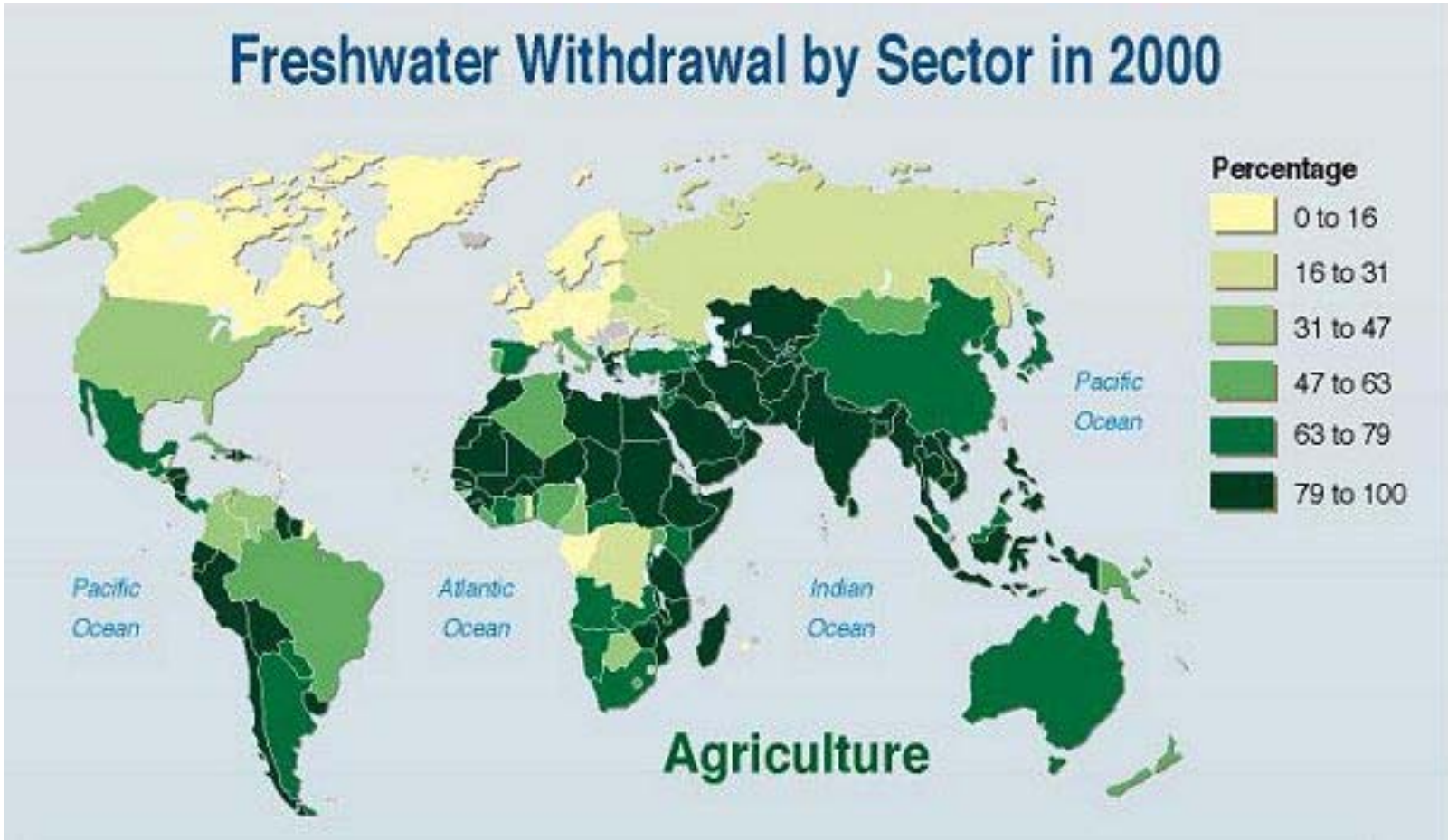


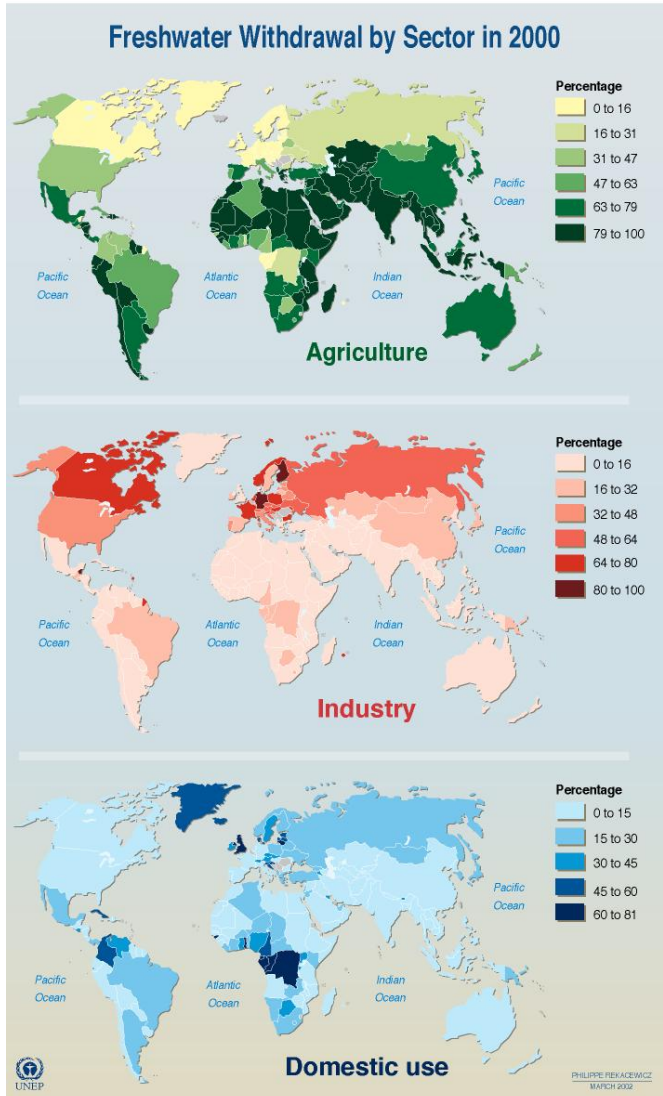
Source: WWF, Free-flowing rivers, p14


Percentage
0 to 16
16 to 32
32 to 48
48 to 64
64 to 80
80 to 100
Pacific Ocean
Atlantic Ocean
Indian Ocean
Pacific Ocean
Industry

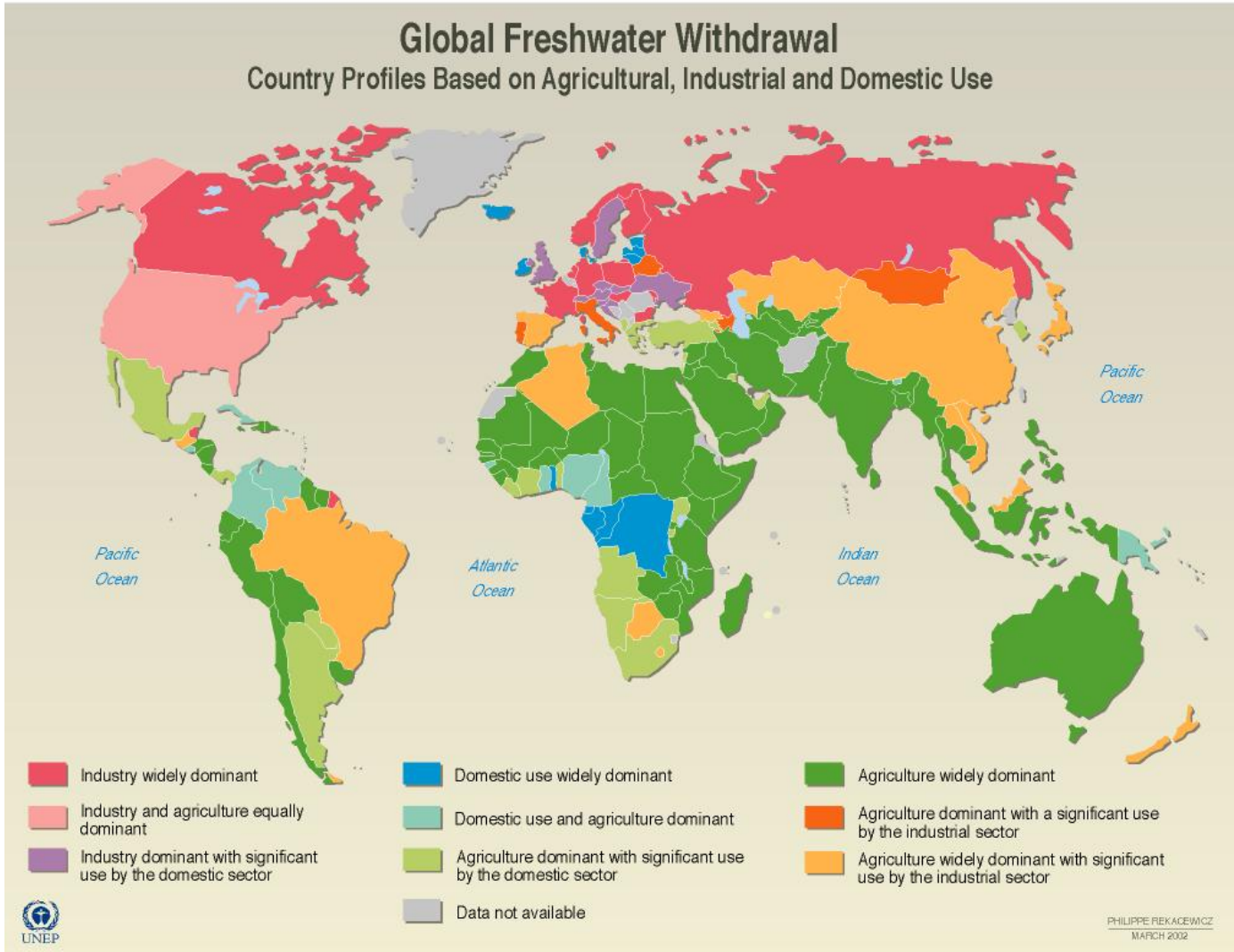

Percentage
0 to 15
15 to 30
30 to 45
45 to 60
60 to 81
Pacific Ocean
Atlantic Ocean
Indian Ocean
Pacific Ocean
Domestic use
UNEP
PHILIPPE REKACEWICZ
MARCH 2002


Domestic Water Use (U.S.), Percent of Total
Carpe Diem:mjperry.blogspot.com
Washing Clothes (21.7%)
Dishwashers (1.4%)
Showers (16.8%)
Other Uses (2.2%)
Toilets (26.7%)
Faucets (15.7%)
Baths (1.7%)
Leaks (13.7%)
Source: American Water Works Association


Freshwater Withdrawal by Sector in 2000
Percentage
0 to 16
16 to 31
31 to 47
47 to 63
63 to 79
79 to 100
Pacific Ocean
Pacific Ocean
Atlantic Ocean
Indian Ocean
Agriculture



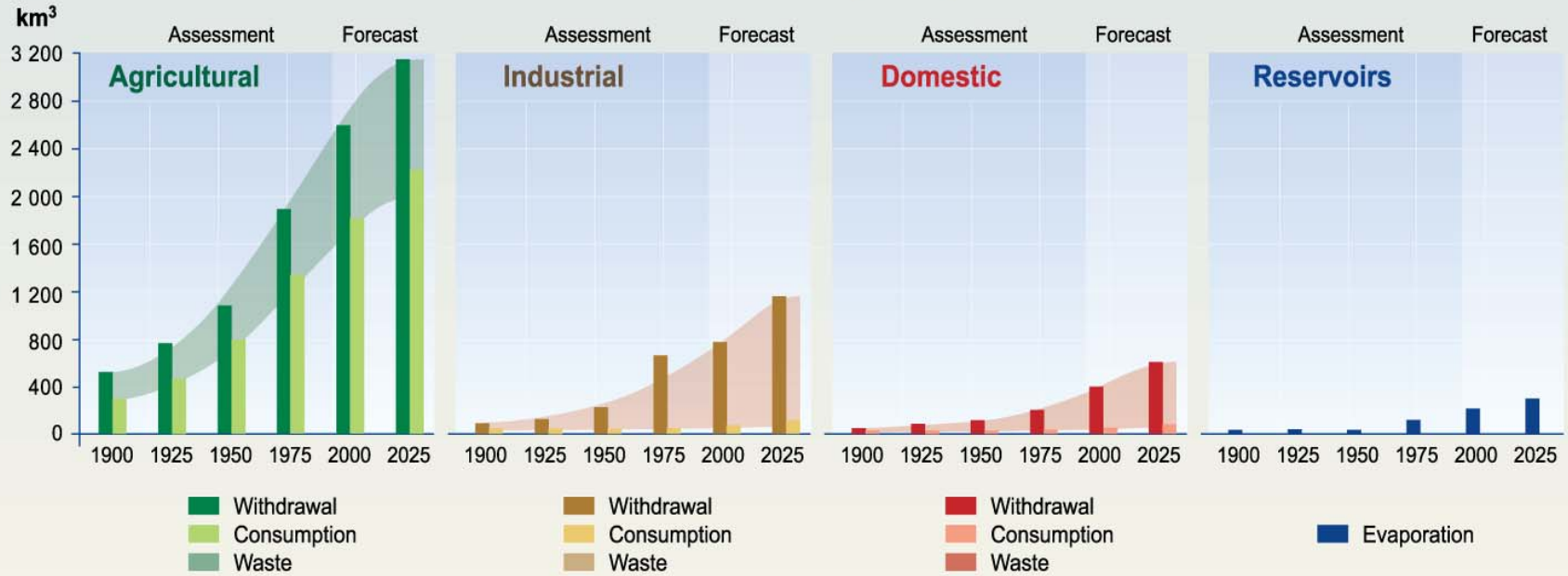
Source: *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.



Source: Based on data fromTable FW1 in *World Resources 2000-2001, People and Ecosystems: The Fraying Web of Life*, World Resources Institute (WRI), Washington DC, 2000.

Evolution of Global Water Use

Withdrawal and Consumption by Sector

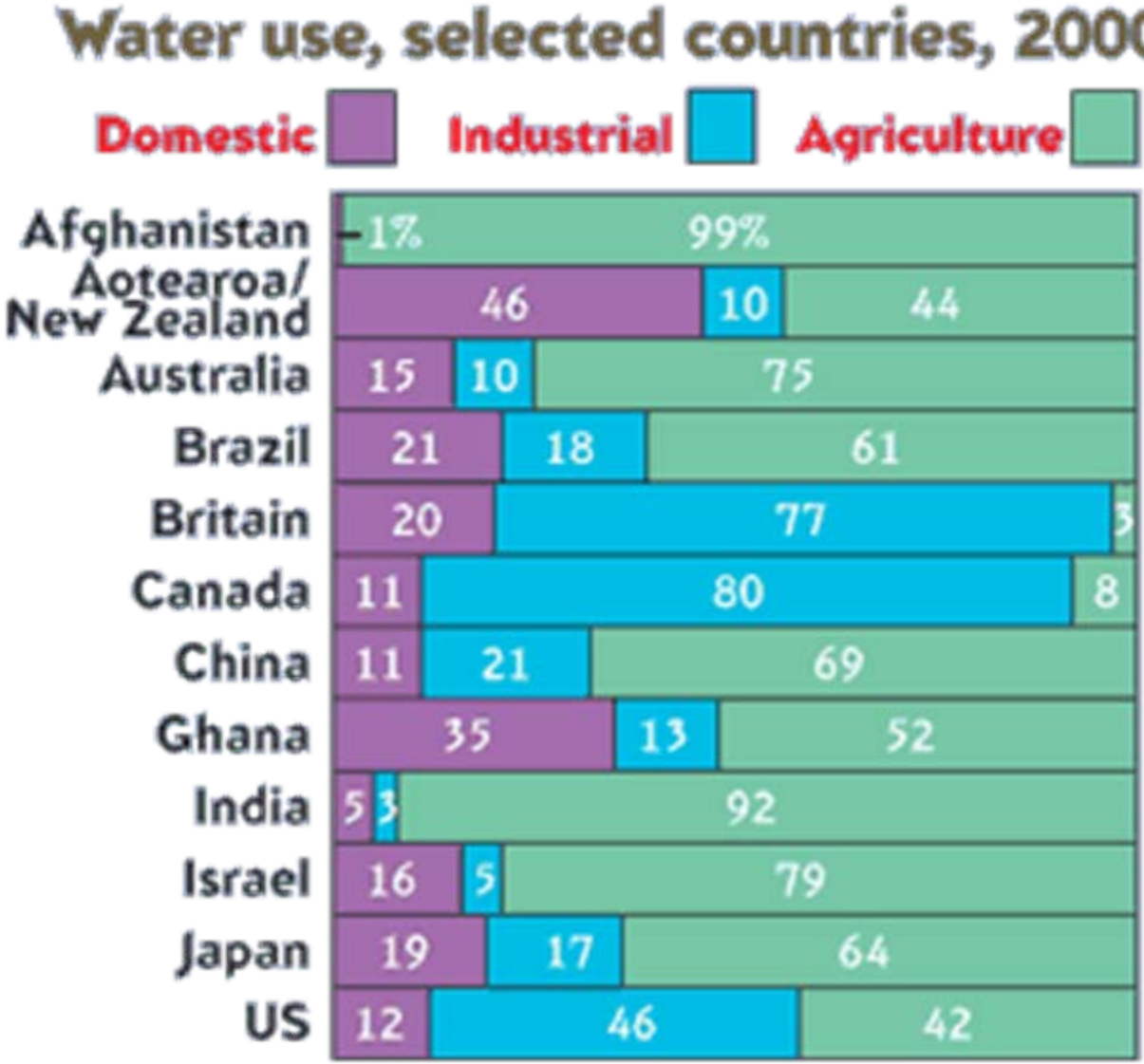


UNEP

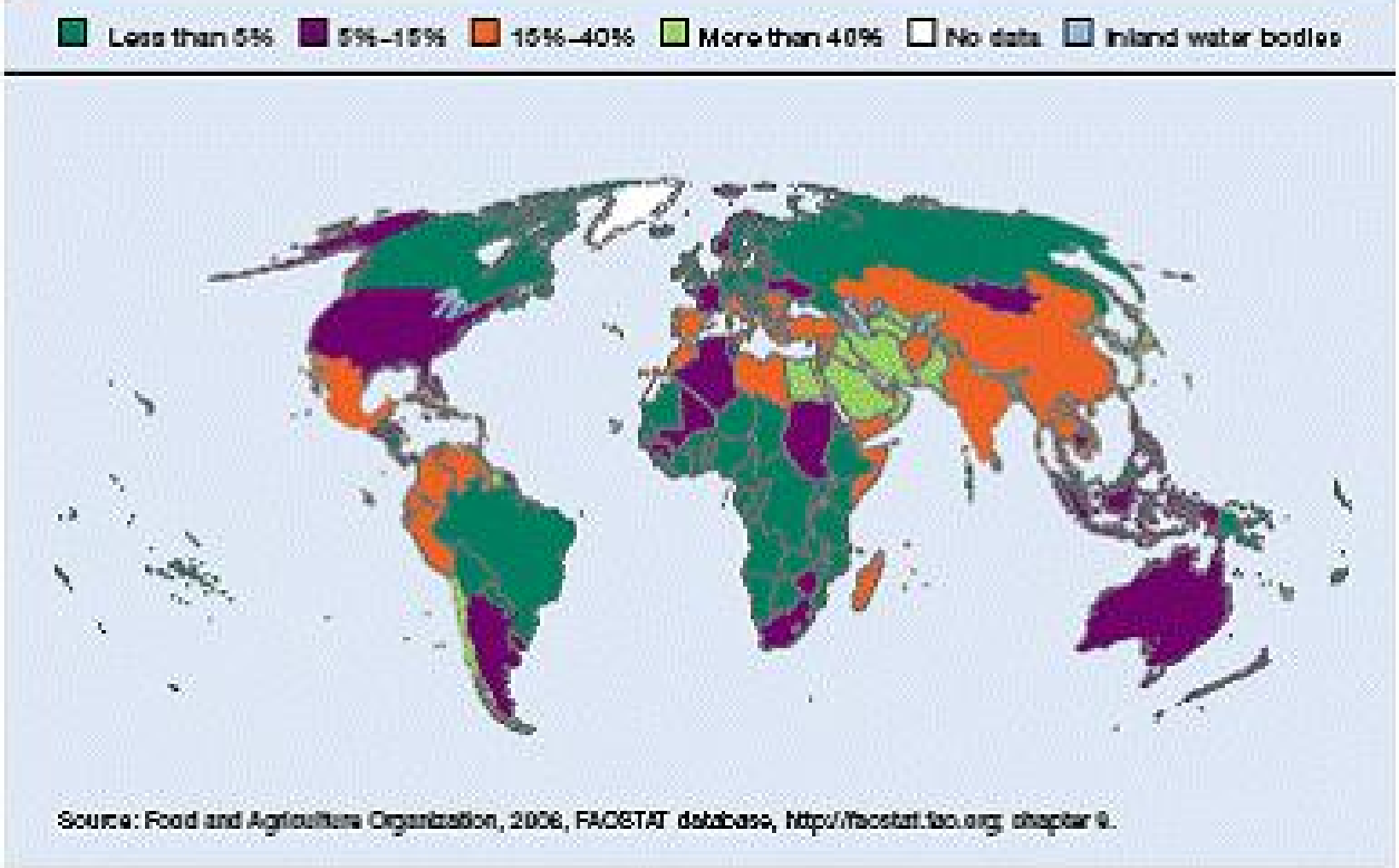
Note: Domestic water consumption in developed countries (500-800 litres per person per day) is about six times greater than in developing countries (60-150 litres per person per day).

PHILIPPE REKACEWICZ
FEBRUARY 2002

Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational,Scientific and Cultural Organisation (UNESCO, Paris), 1999.


Water use, selected countries, 2000³
Domestic
Industrial
Agriculture
Afghanistan
Aotearoa/ New Zealand
Australia
Brazil
Britain
Canada
China
Ghana
India
Israel
Japan
US
1%
99%
46
10
44
15
10
75
21
18
61
20
77
3
11
80
8
11
21
69
35
13
52
5
3
92
16
5
79
19
17
64
12
46
42

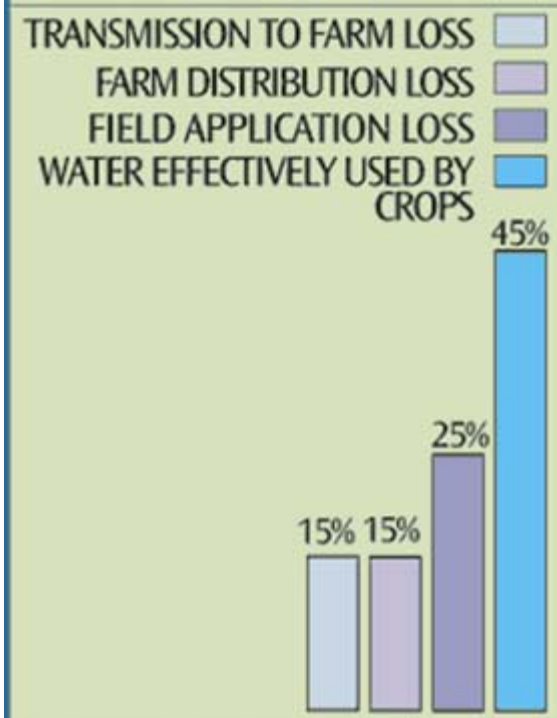
map 4 | Area under irrigation as a share of cultivated land



Source: Food and Agriculture Organization, 2006, FAOSTAT database, http://faostat.fao.org, chapter 9.

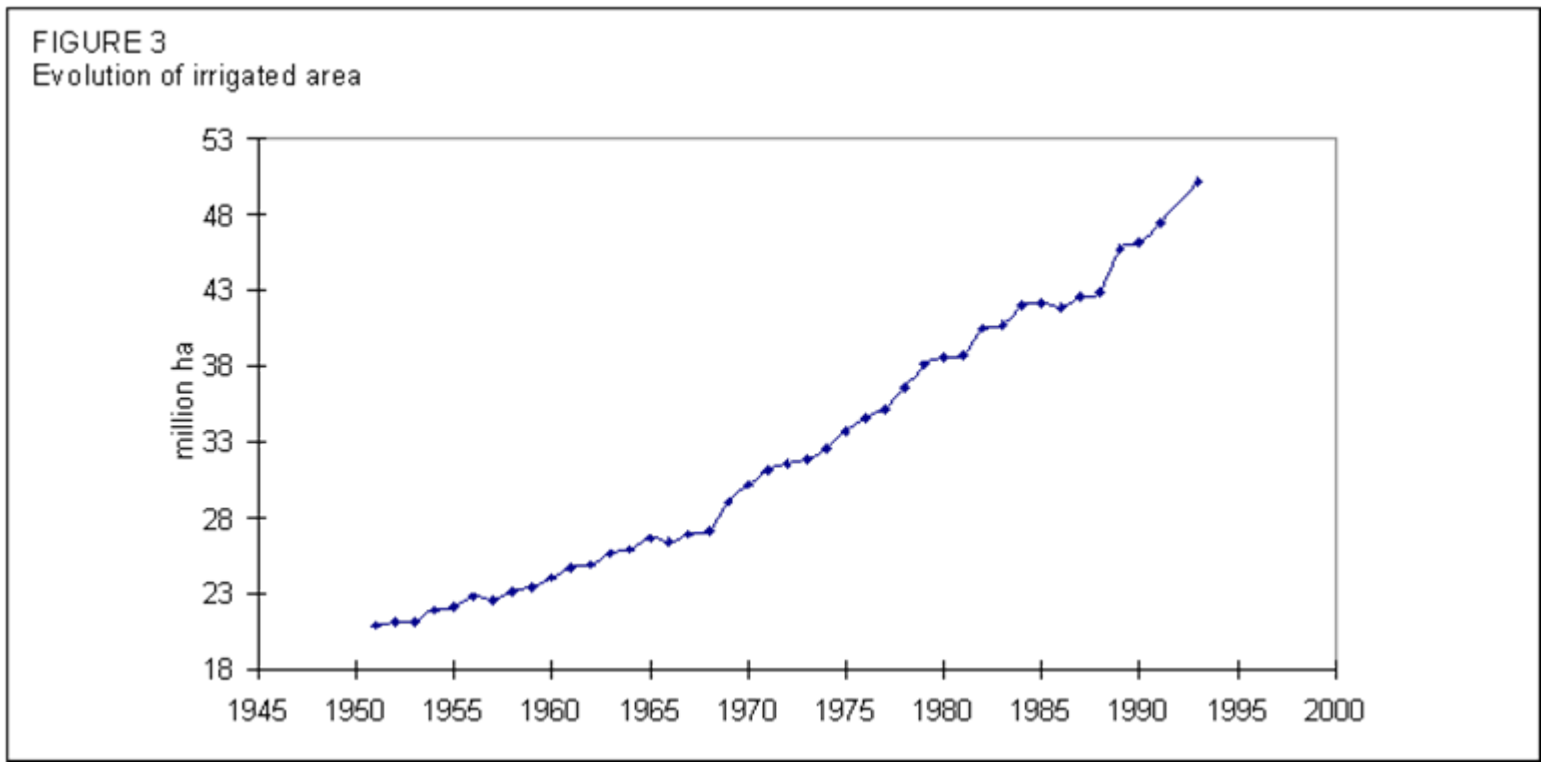
ESTIMATED WATER LOST IN AGRICULTURAL IRRIGATION

40% OF ALL AGRICULTURAL PRODUCTION DEPENDS ON IRRIGATION

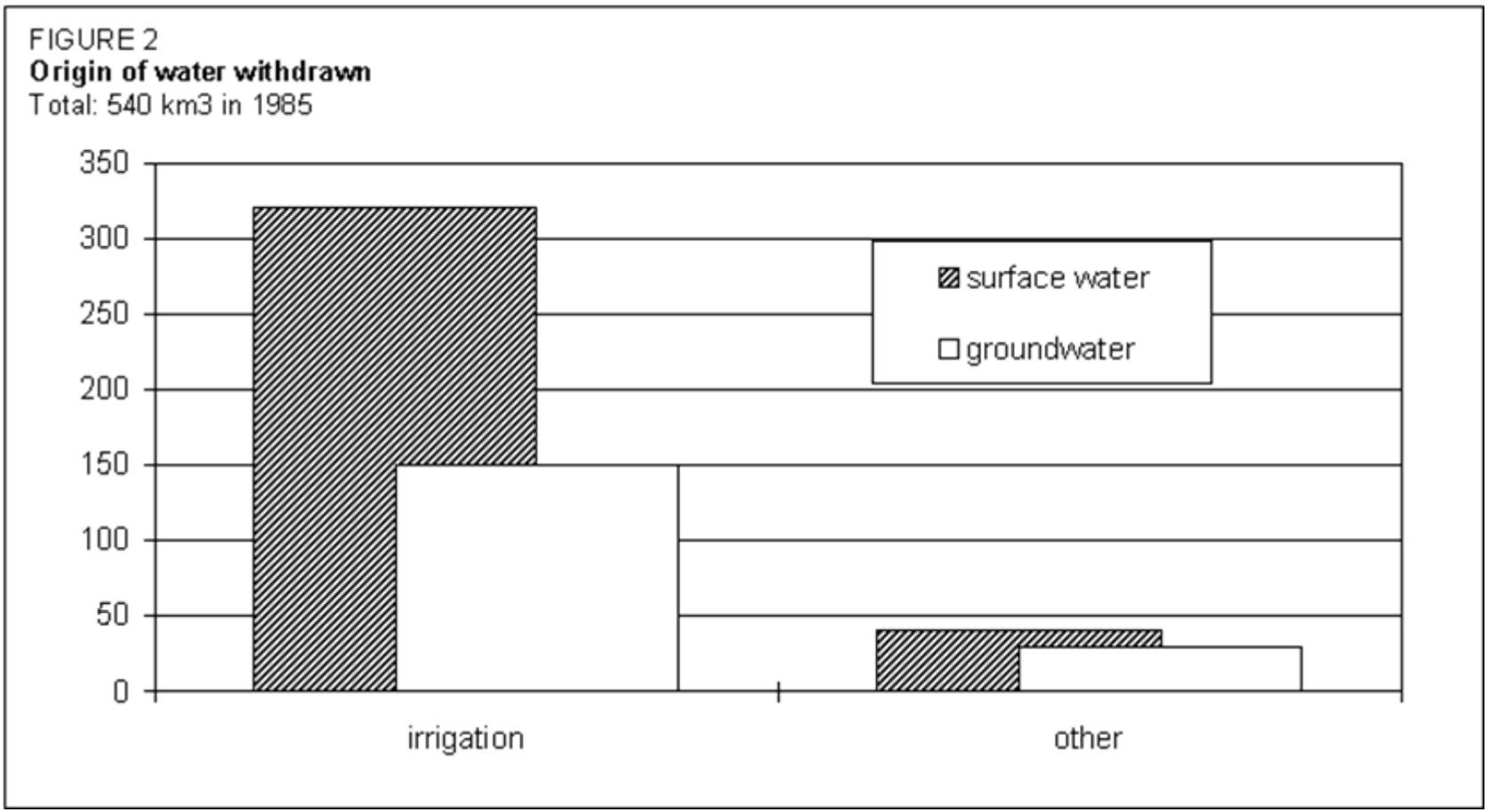


Source: UNESCO World Water Assessment Programme, www.unesco.org
World Commission on Dams, www.dams.org/report/report_factsheet.htm

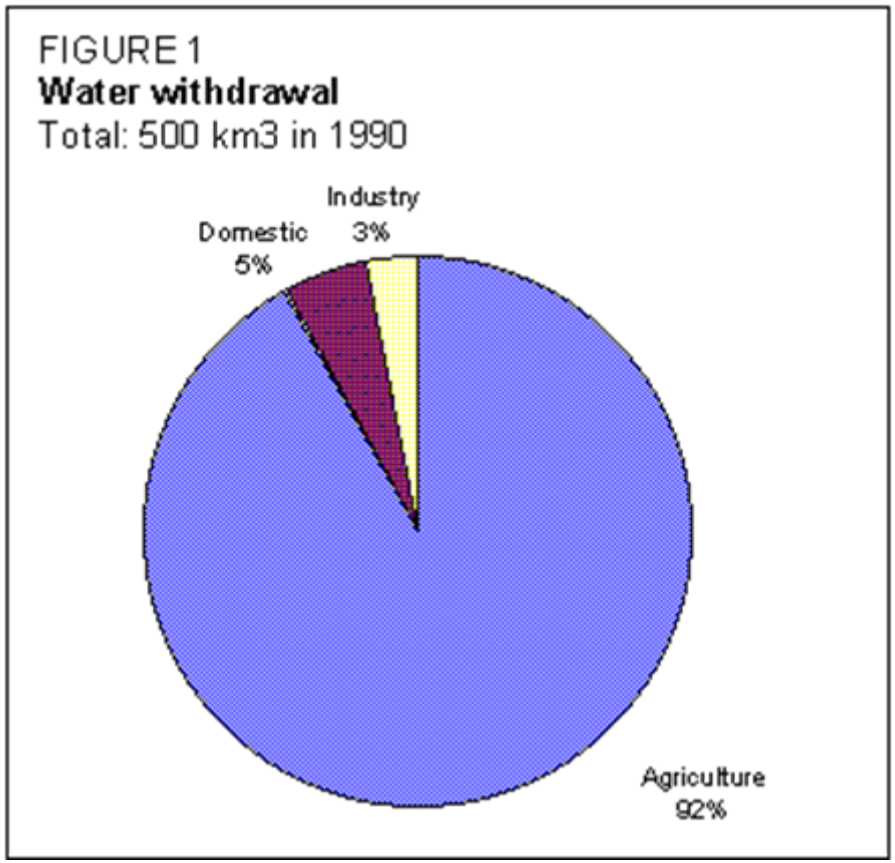
Irrigation in India



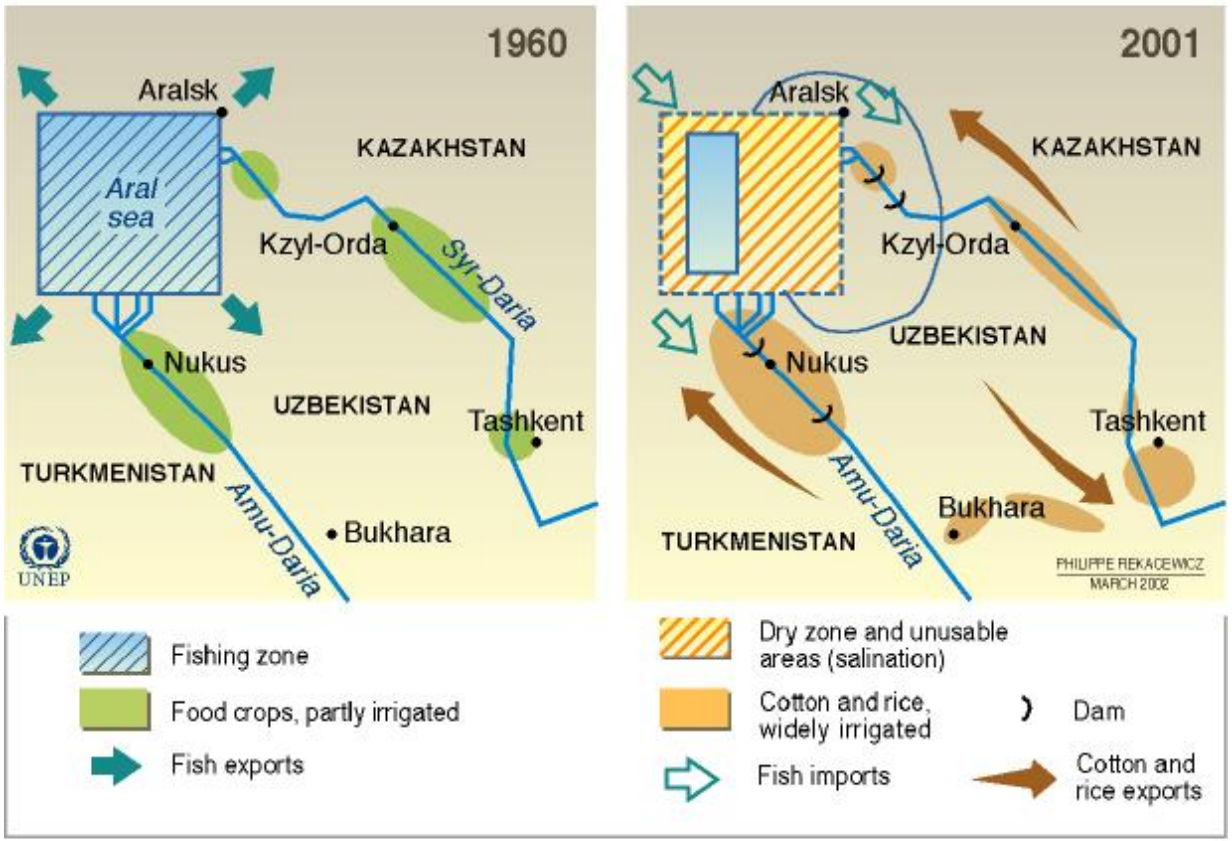
Irrigation In India



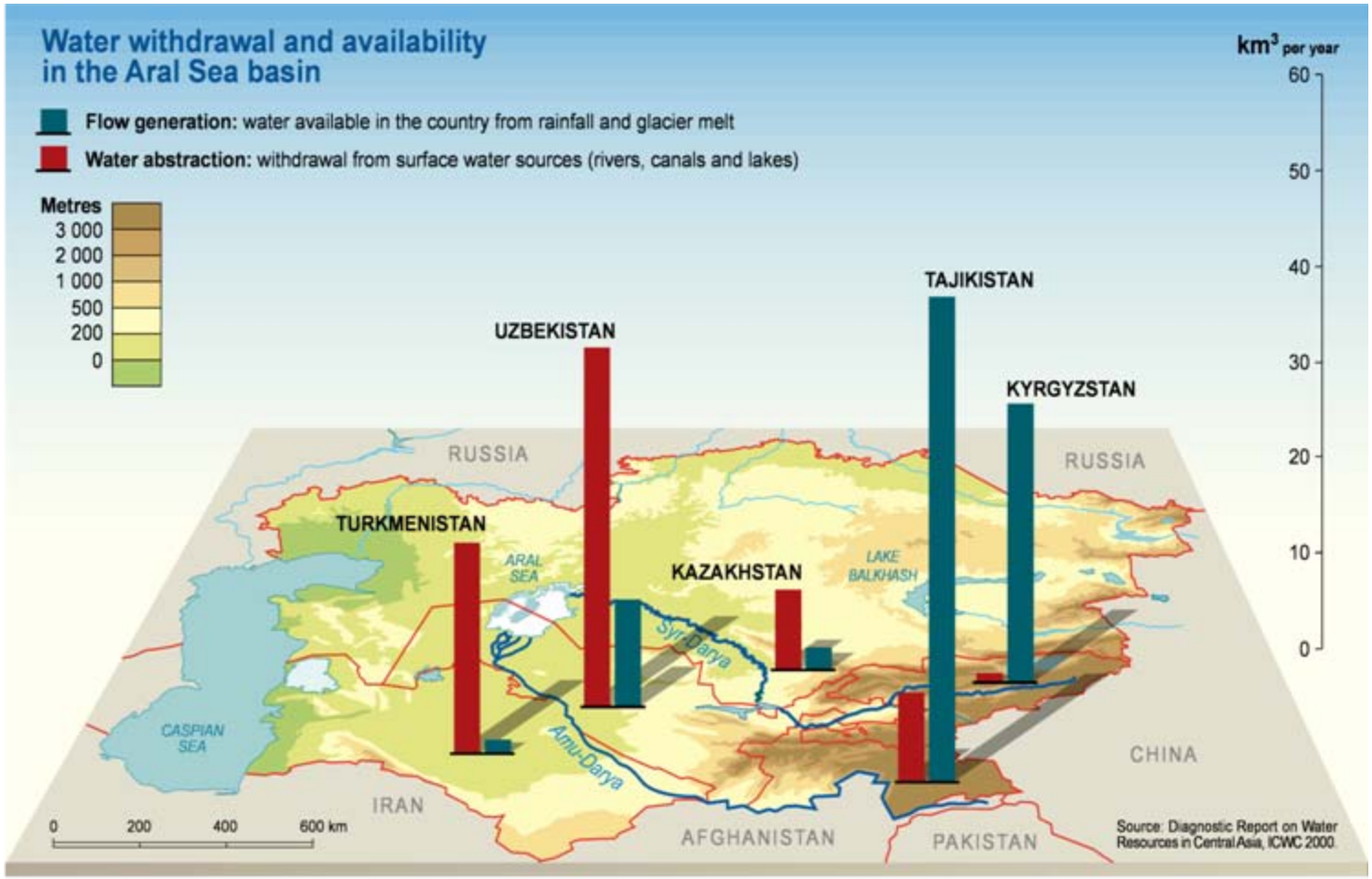
Irrigation in India



The Shrinking of the Aral Sea: Socio-Economic Impacts



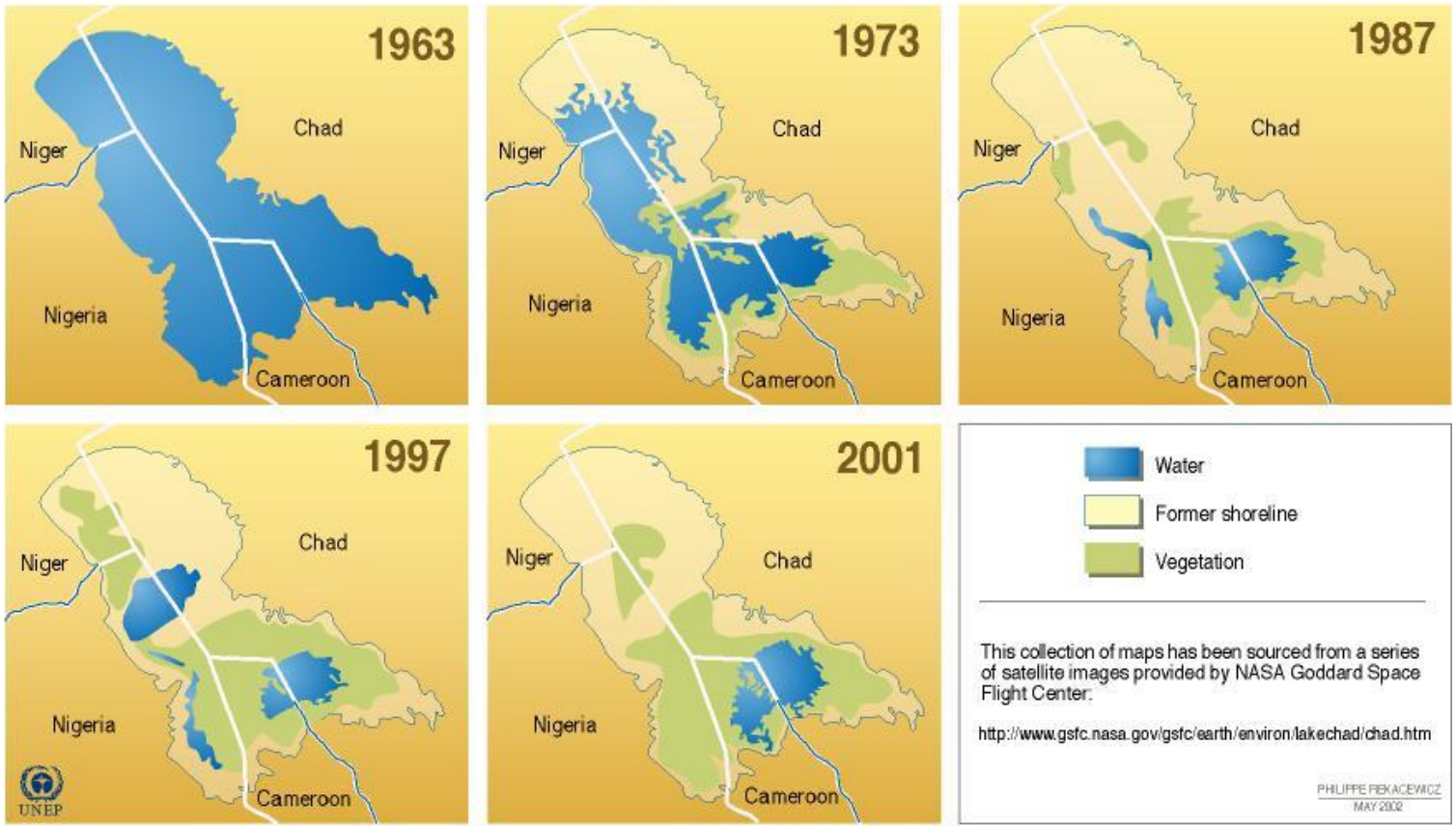
Source: Philippe Rekacewicz, *An Assassinated Sea*, in Histoire-Géographie, initiation économique, page 333, Classe de Troisième, Hatier, Paris, 1993 (data updated in 2002); *L'état du Monde*, 1992 and 2001 editions, La Découverte, Paris.

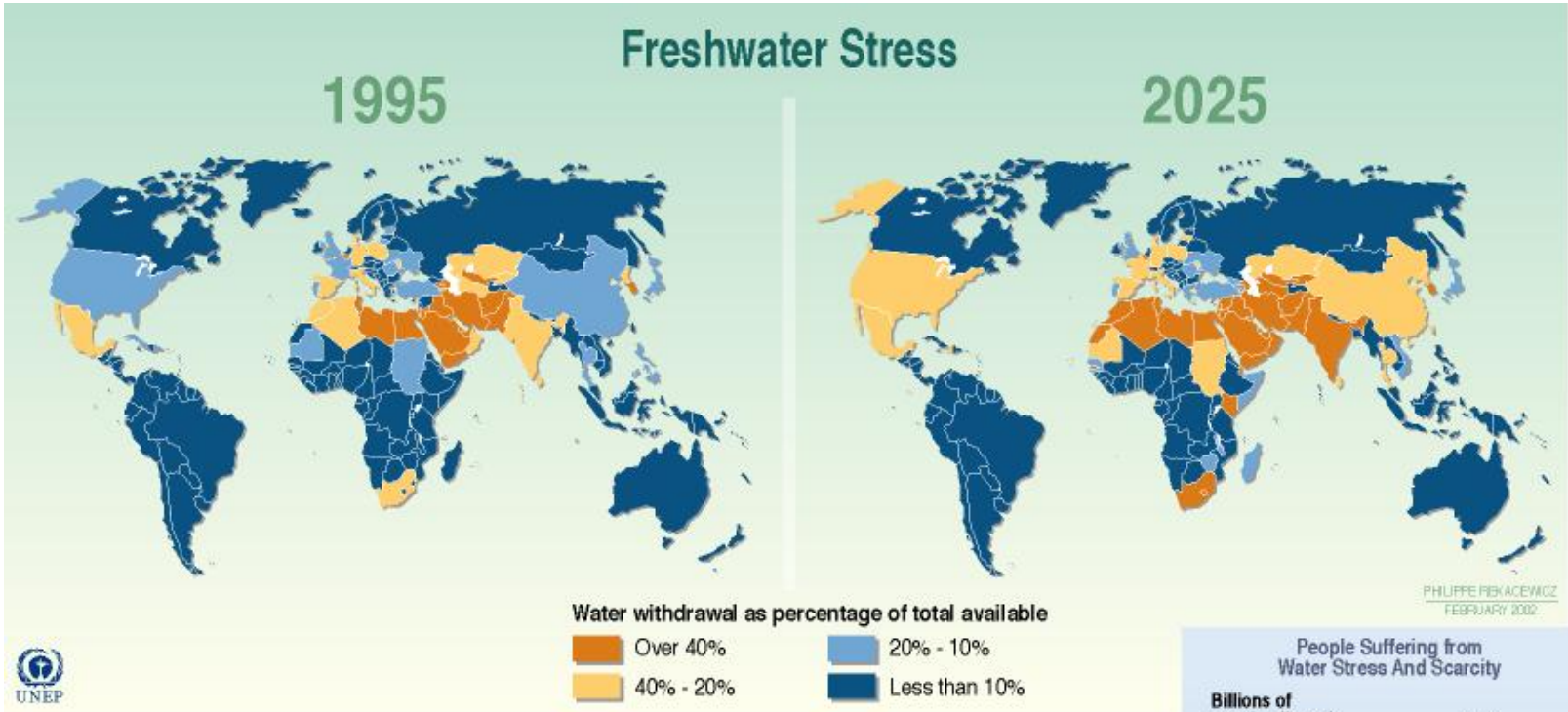


MAP BY VIKTOR NOVIKOV AND PHILIPPE REKACEWICZ - UNEP/GRID-ARENDAL - APRIL 2005

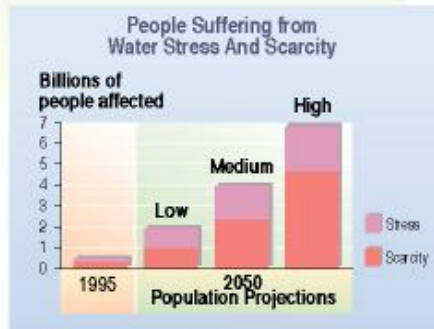
A Chronology of Change

Natural and Anthropogenic Factors Affecting Lake Chad





Source: World Meteorological Organisation (WMO), Geneva, 1996; Global Environment Outlook 2000 (GEO), UNEP, Earthscan, London, 1999.



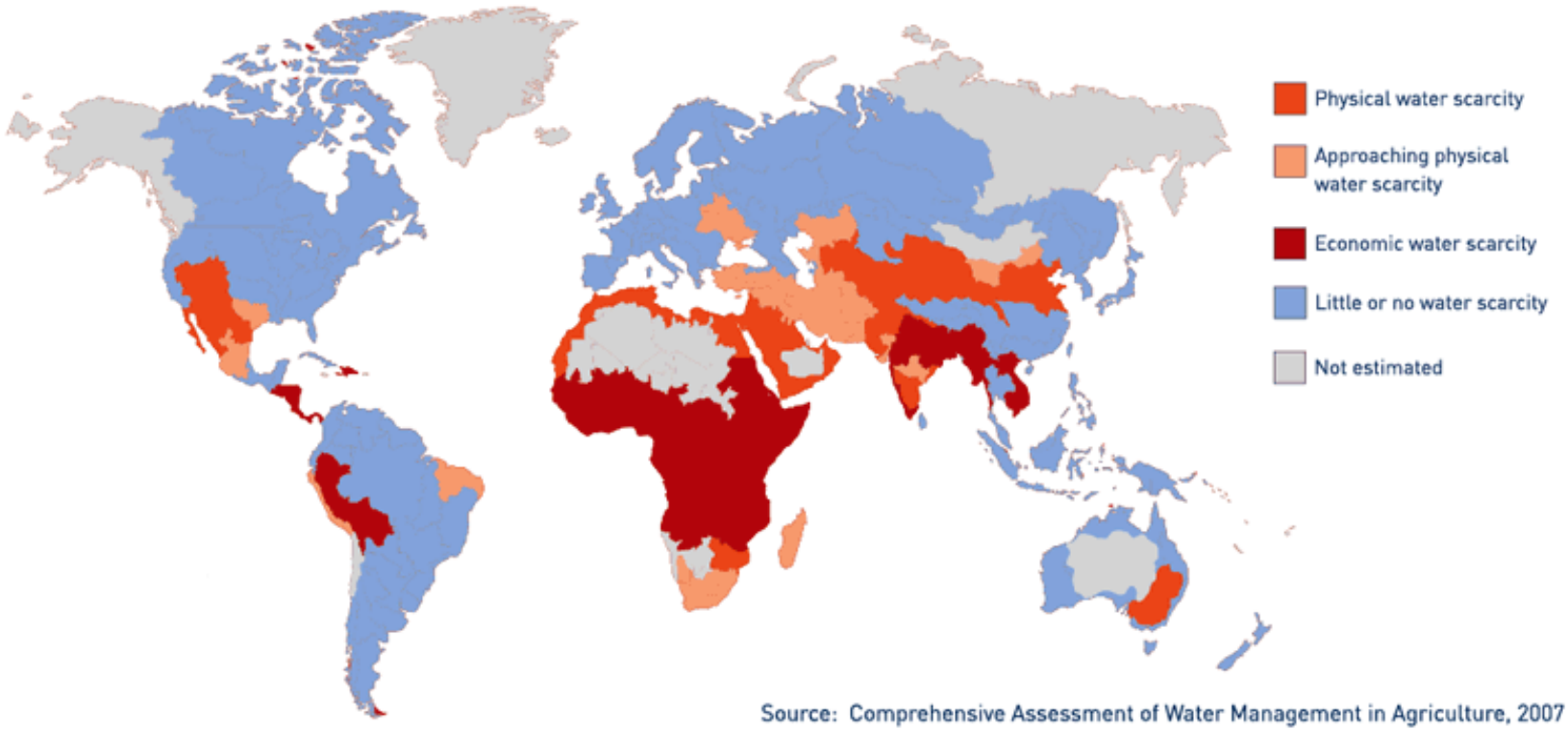
AREAS OF PHYSICAL AND ECONOMIC WATER SCARCITY

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.

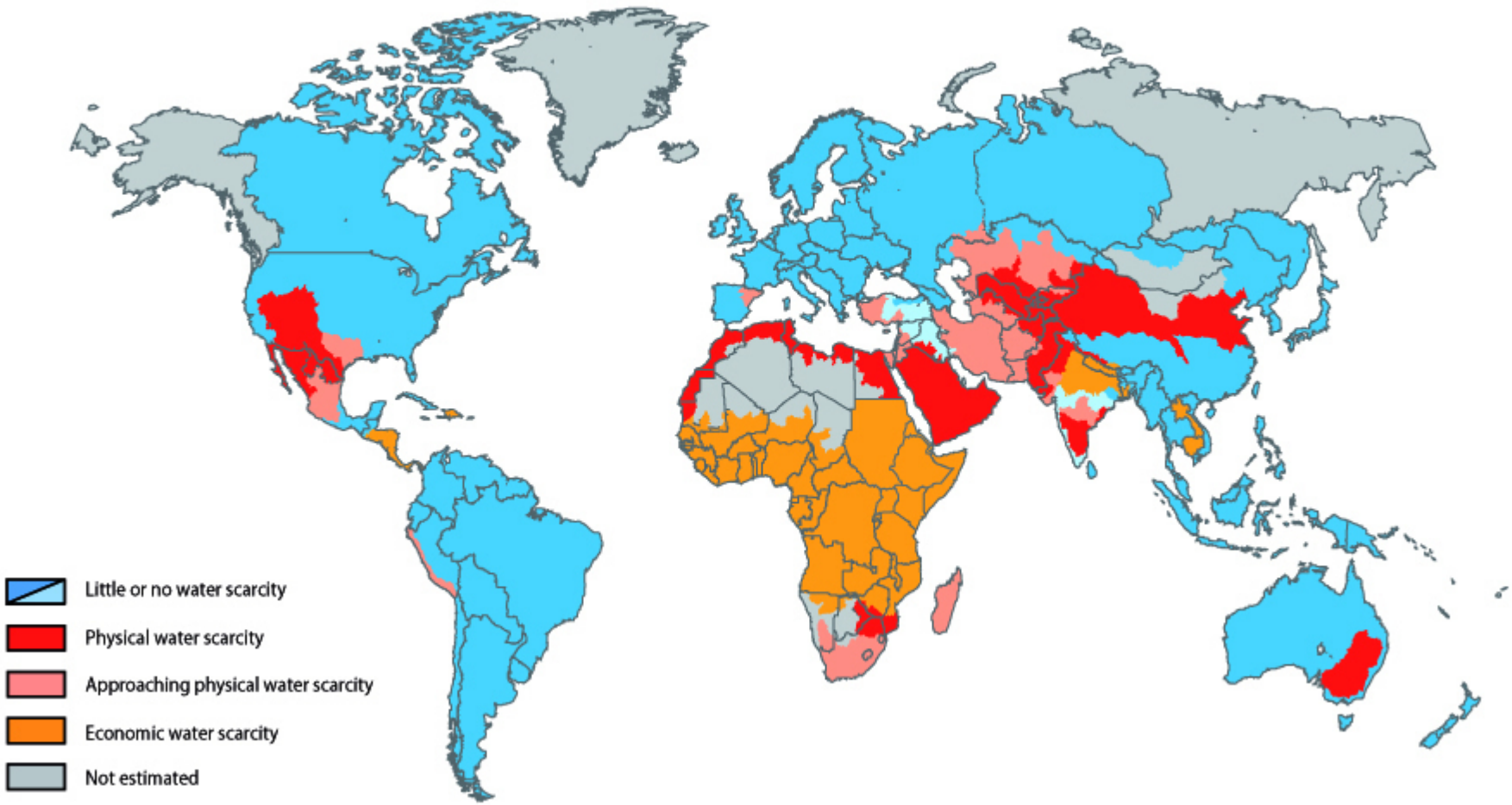
Economic water scarcity (human, institutional, and financial capital limit access to water even though water in nature is available locally to meet human demands). Water resources are abundant relative to water use, with less than 25% of water from rivers withdrawn for human purposes, but malnutrition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

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

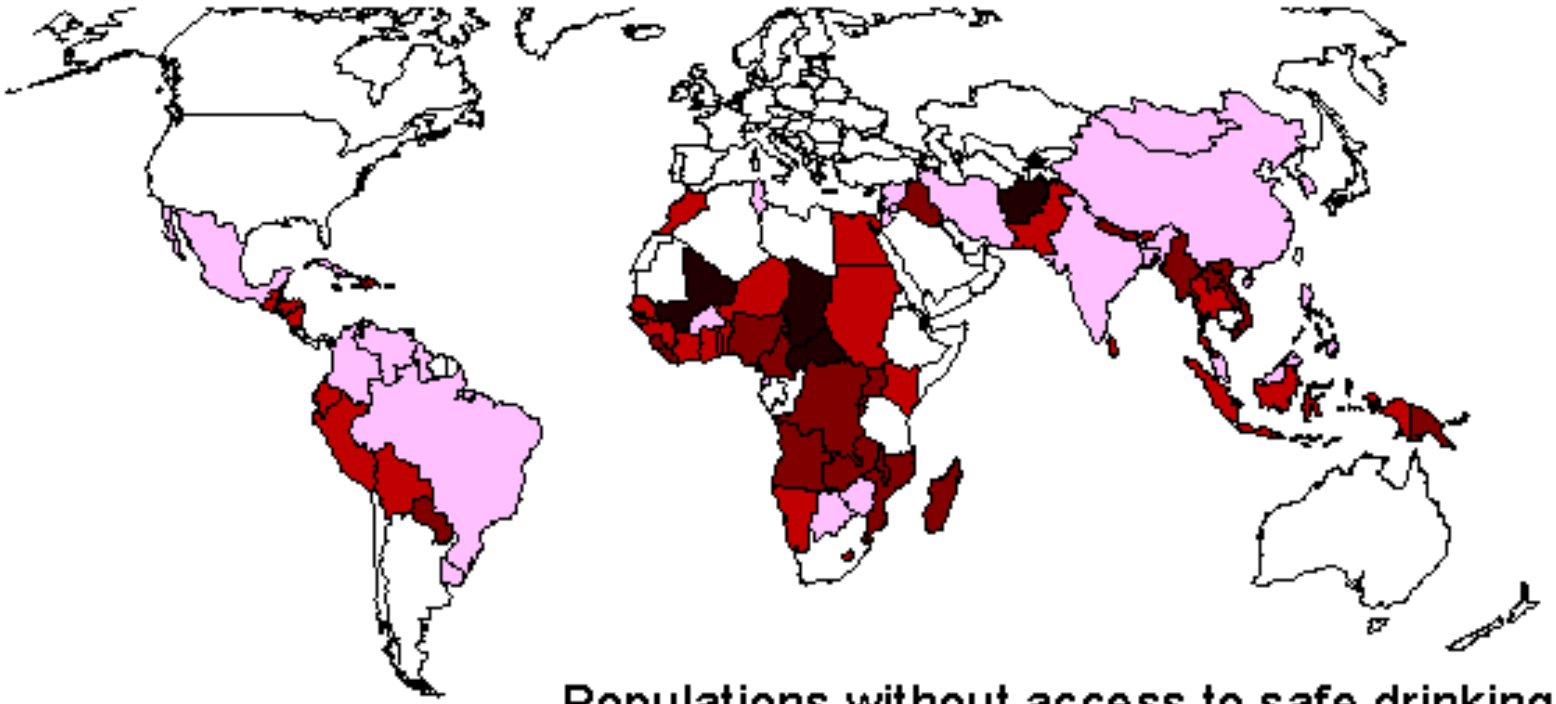


Source: Comprehensive Assessment of Water Management in Agriculture, 2007

Areas of physical and economic water scarcity

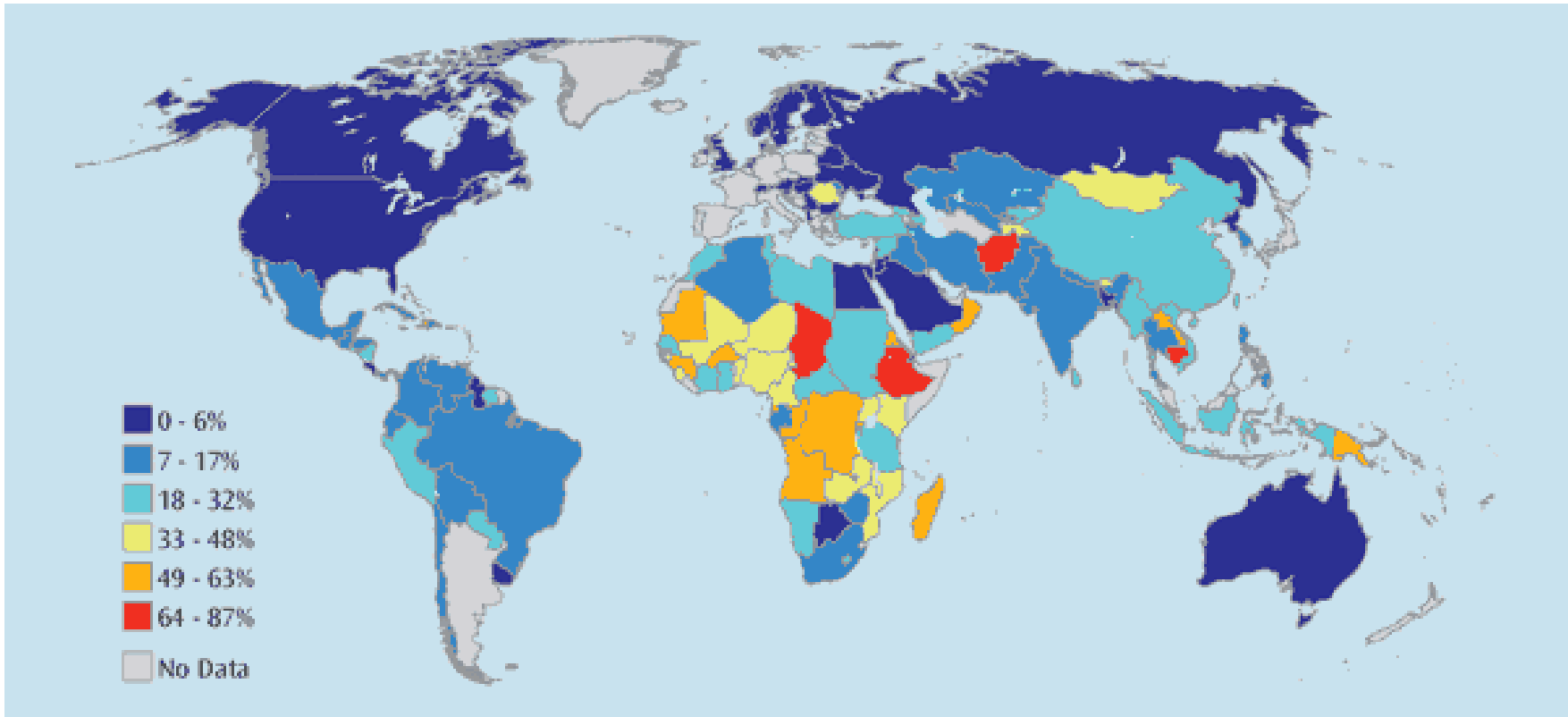


Source: IMWI report, Insights from the Comprehensive Assessment of Water Management in Agriculture, 2006 / p8

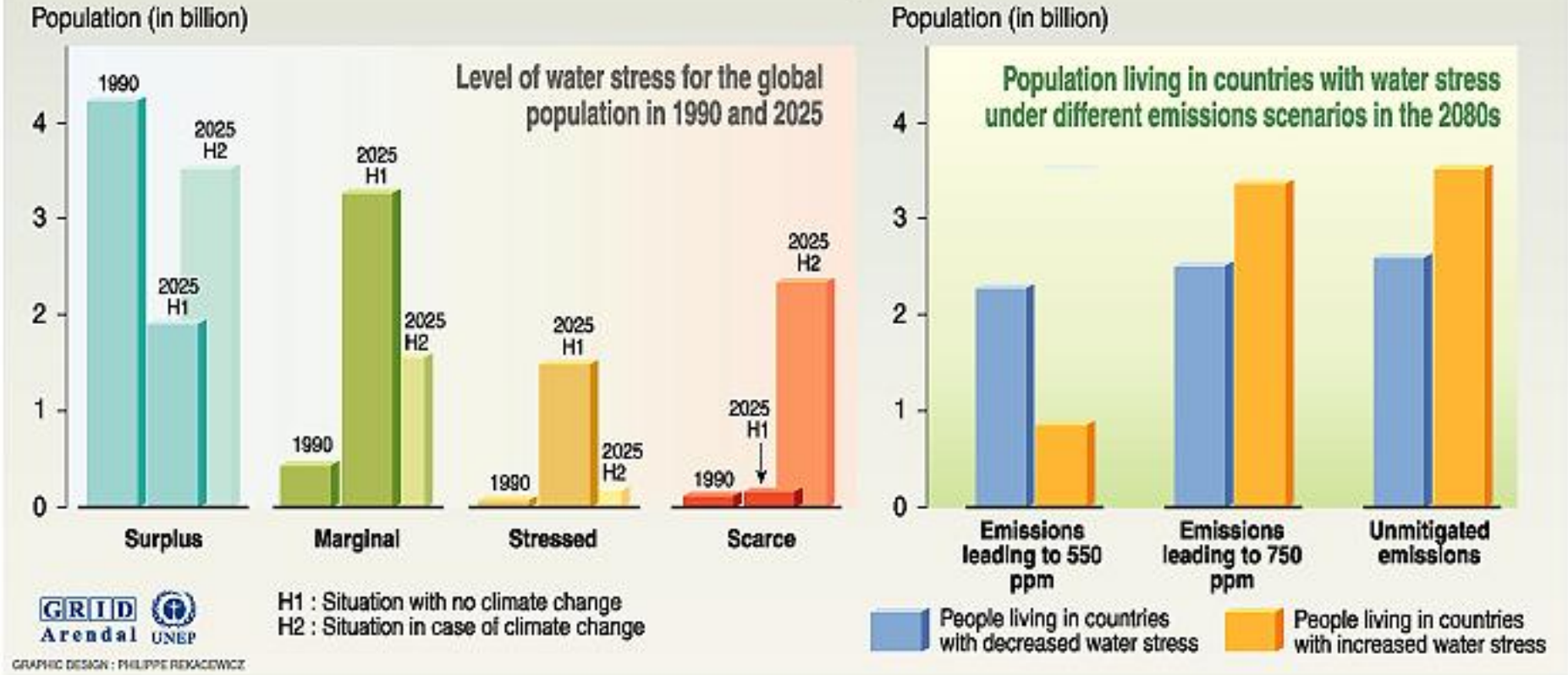


Populations without access to safe drinking water

from The World's Water
The Biennial Report on Freshwater Resources
(Gleick 1998)


0 - 6%
7 - 17%
18 - 32%
33 - 48%
49 - 63%
64 - 87%
No Data

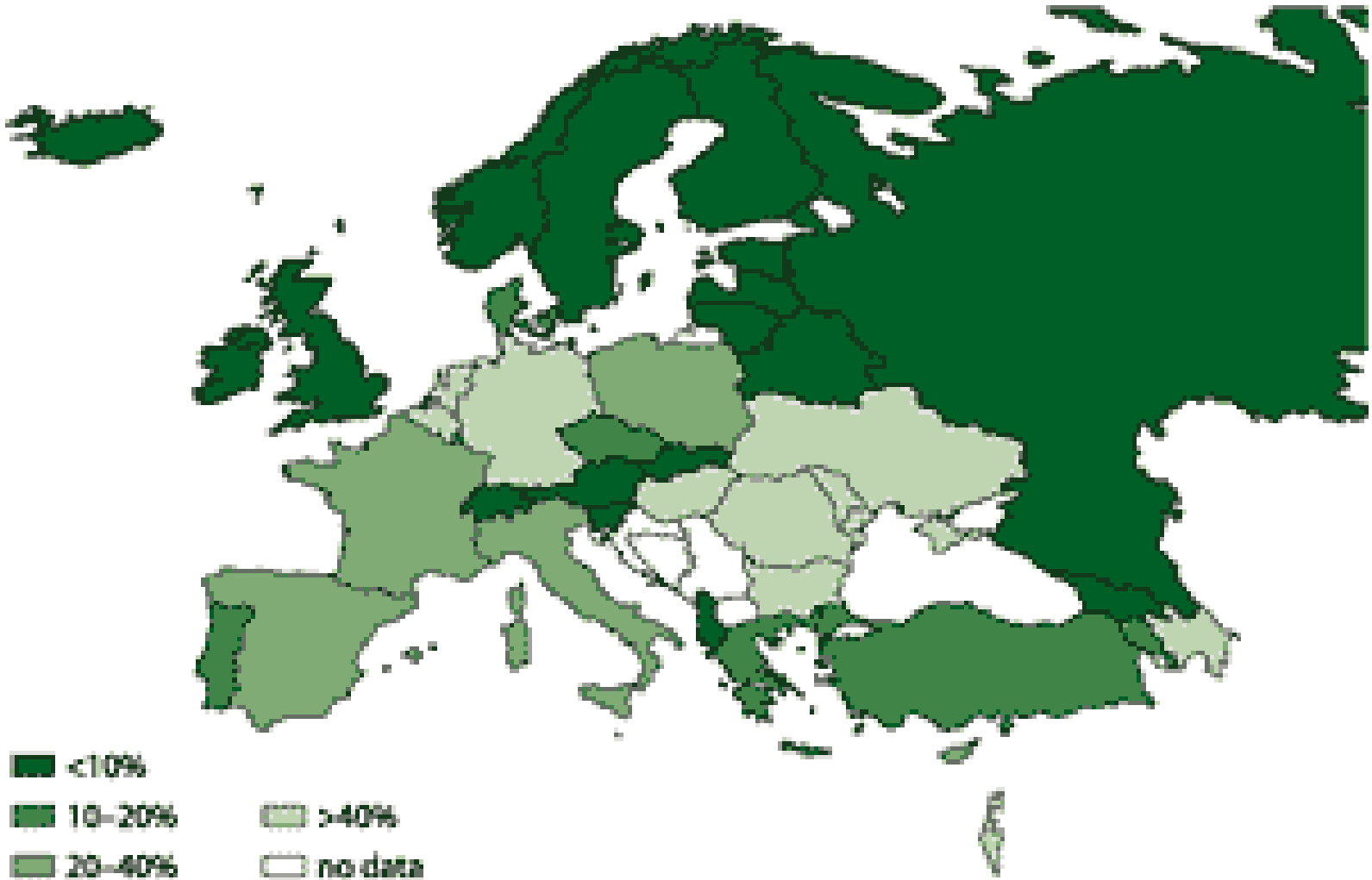
Freshwater stress: Current population at risk

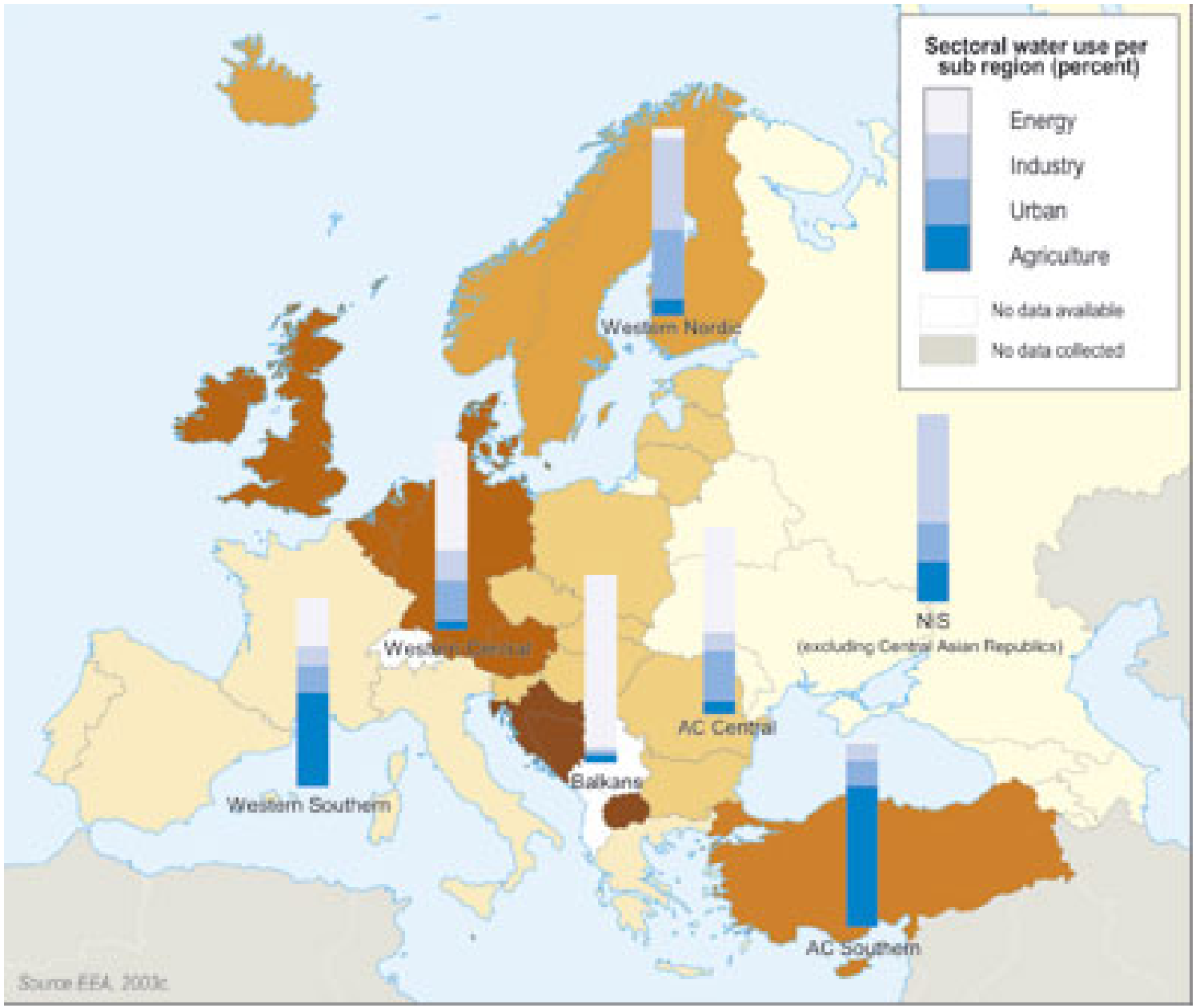


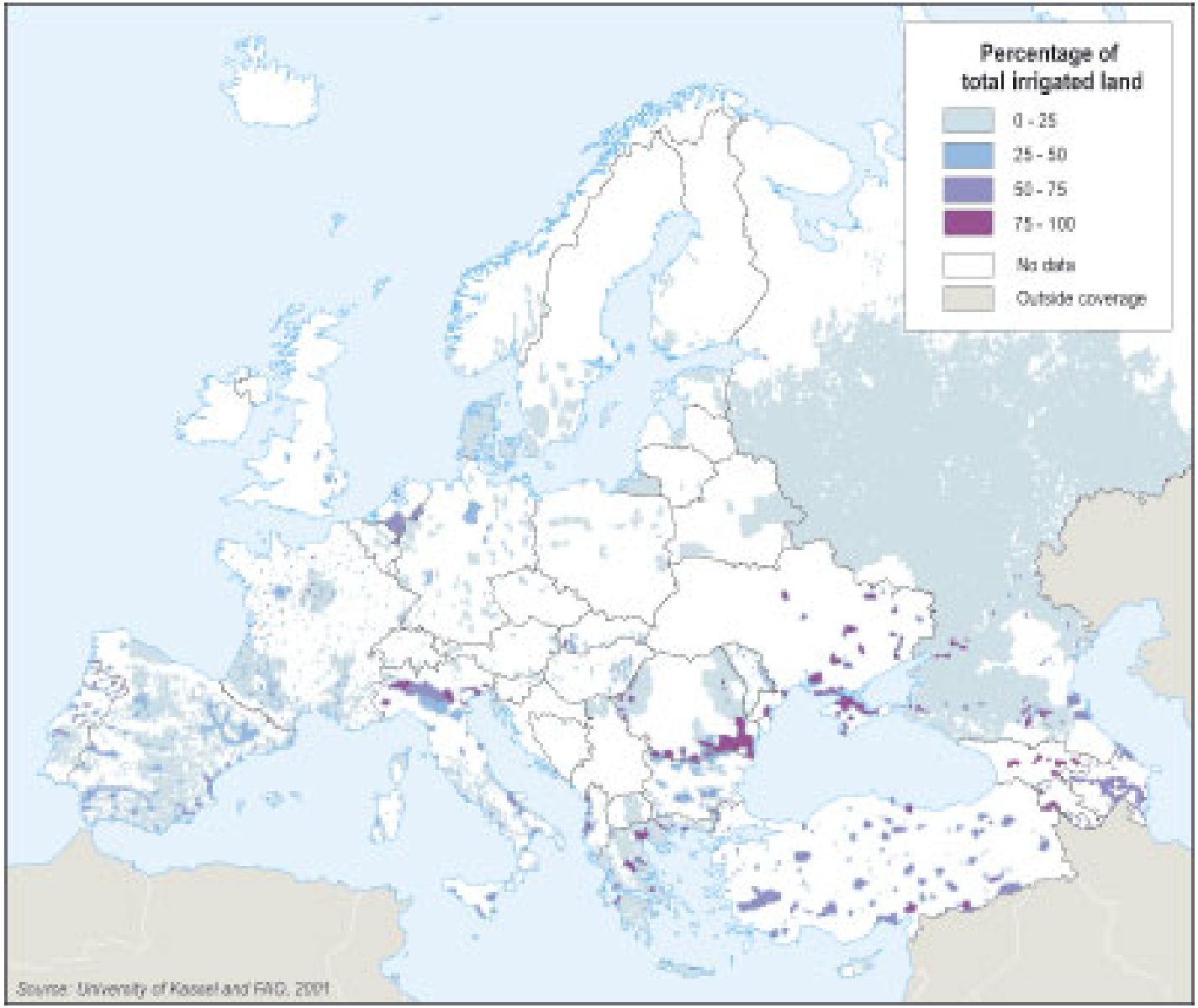
Source: Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996; Climate change and its impacts, stabilisation of CO2 in the atmosphere, Hadley centre for climate prediction and research,the meteorological office, London, 1999.

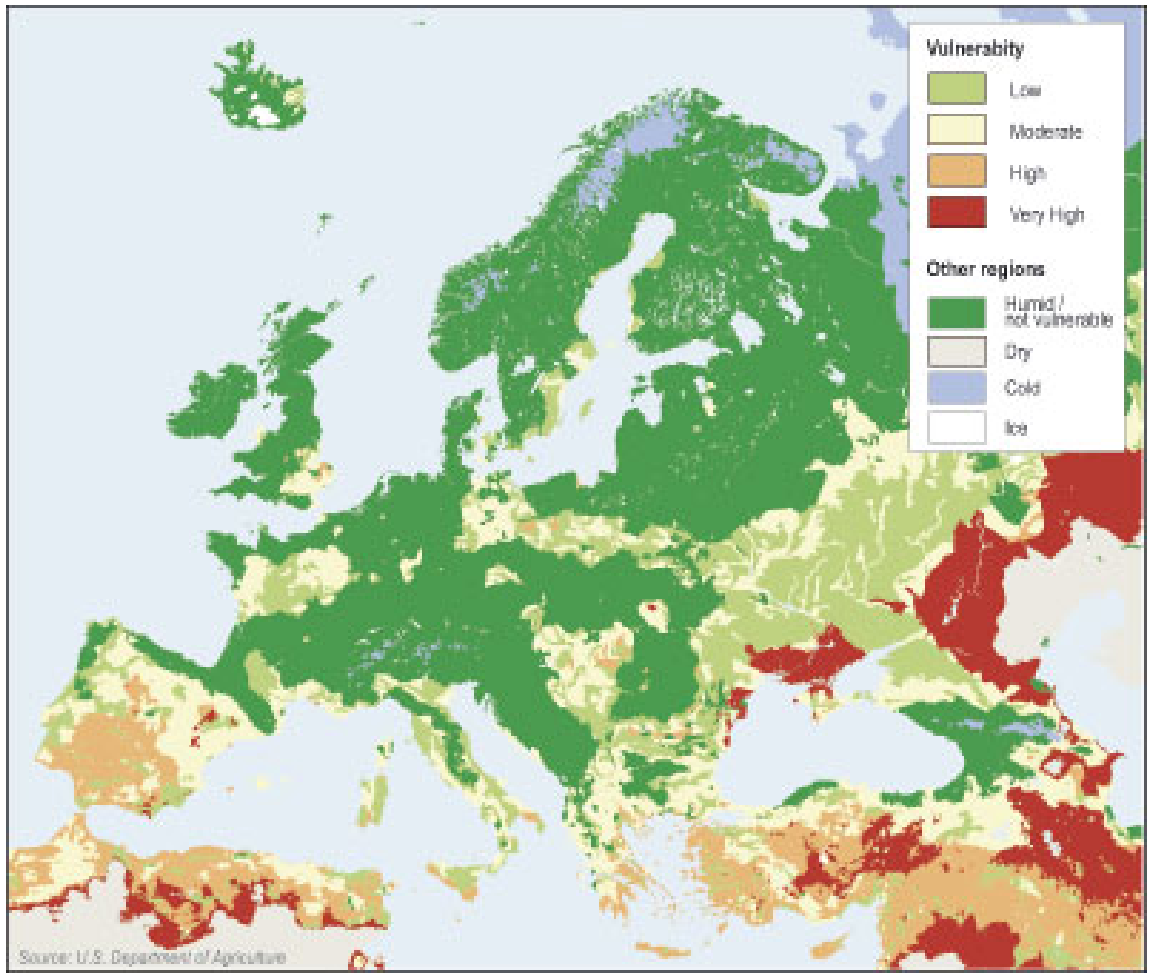
Water Stress in Europe

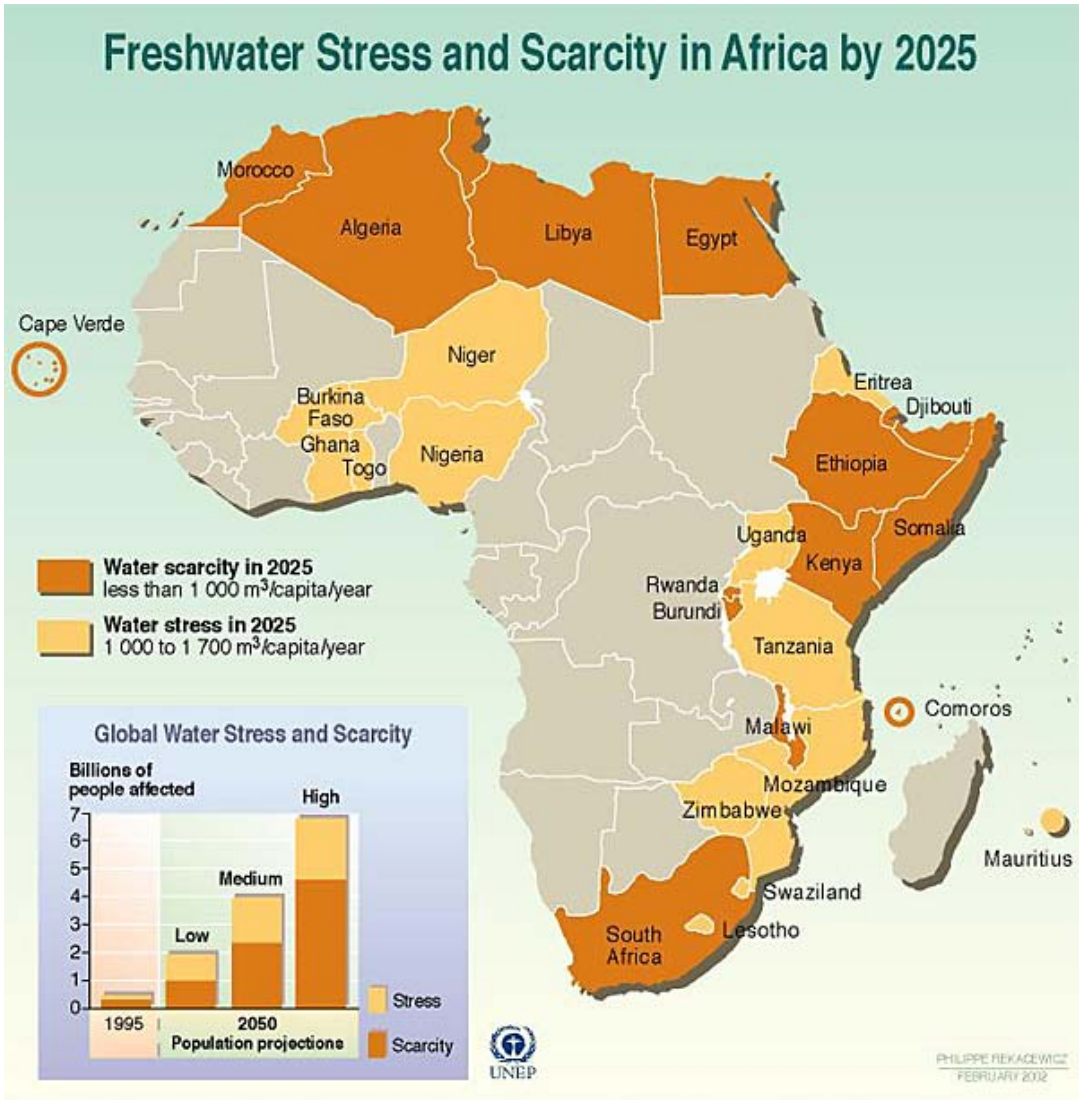
Withdrawals as % of renewable resources



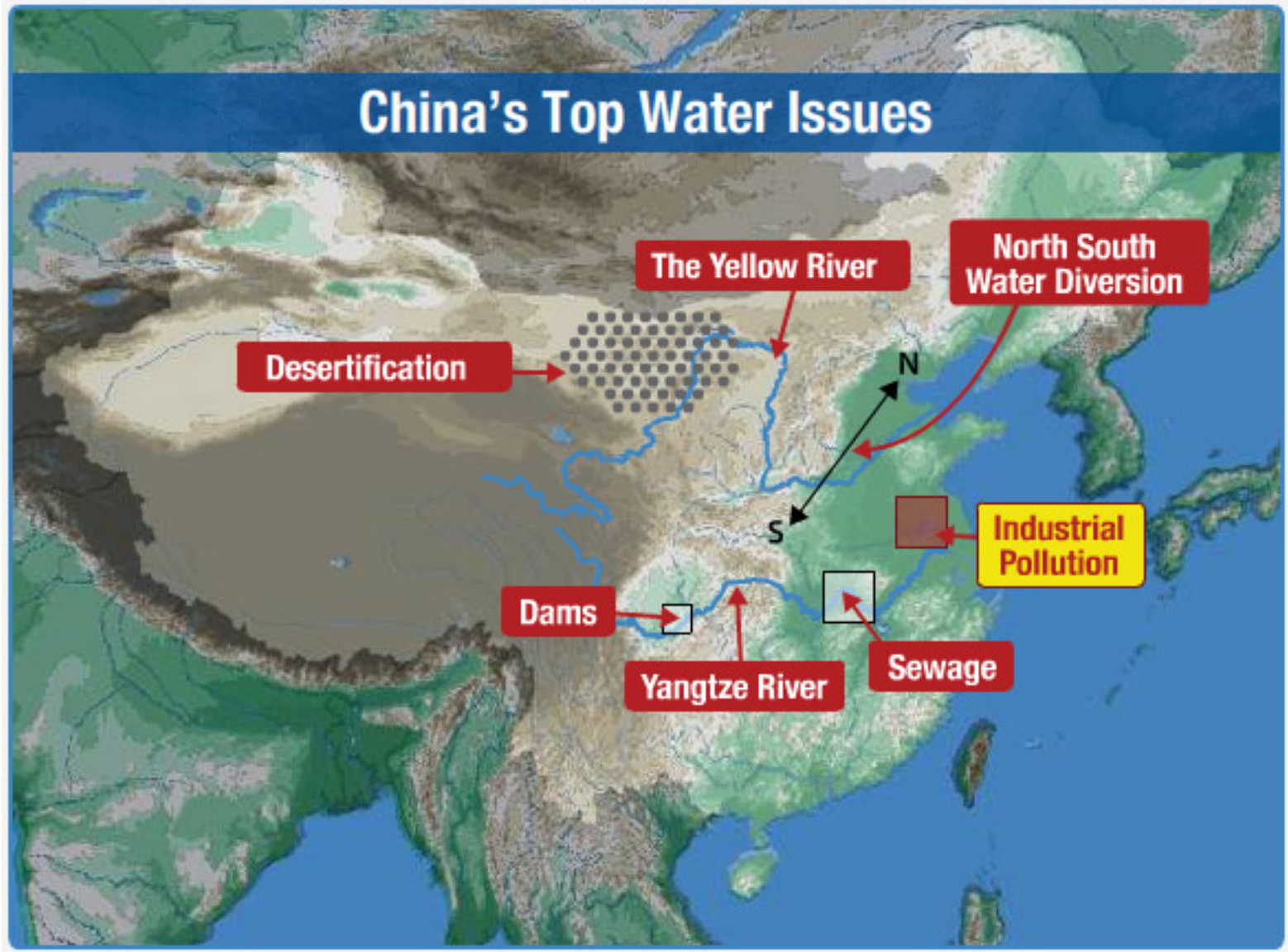

Sectoral water use per sub region (percent)
Energy
Industry
Urban
Agriculture
No data available
No data collected
Western Nordic
Western Central
Western Southern
Balkans
AC Central
NIS
(excluding Central Asian Republics)
AC Southern
Source EEA, 2003c

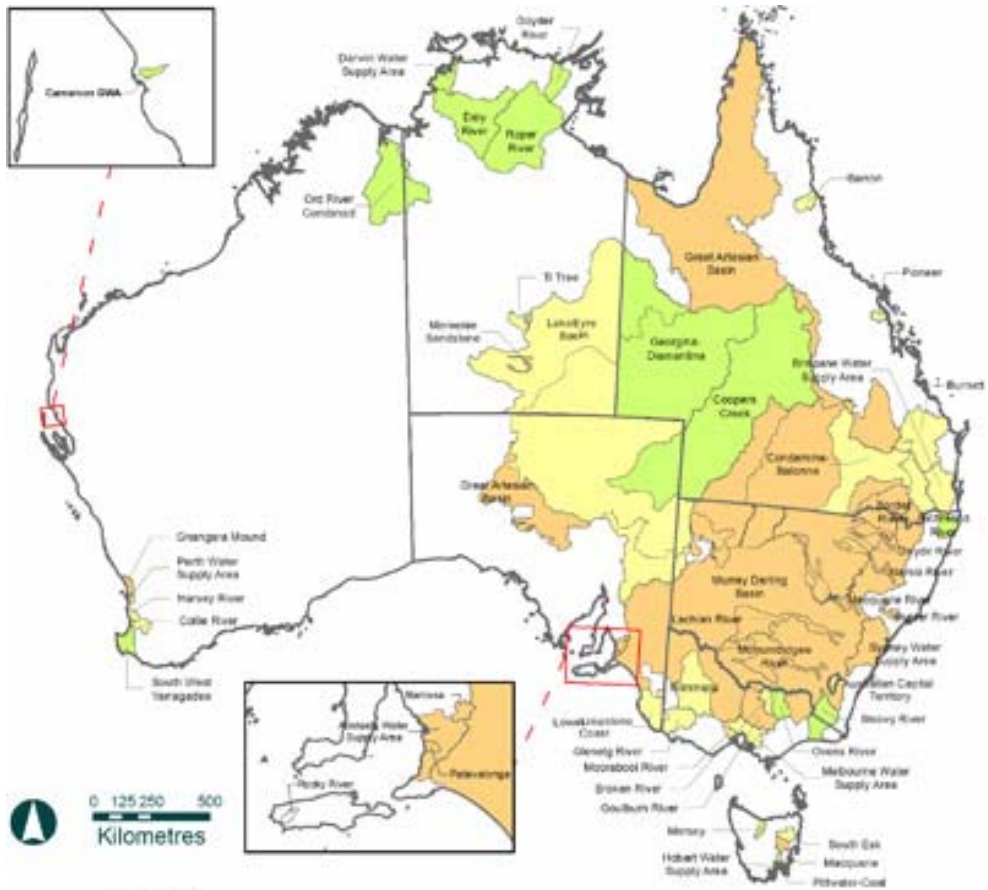

Percentage of total irrigated land
0 - 25
25 - 50
50 - 75
75 - 100
No data
Outside coverage
Source: University of Kassel and FAO, 2001


Vulnerability
Low
Moderate
High
Very High
Other regions
Humid / not vulnerable
Dry
Cold
Ice
Source: U.S. Department of Agriculture



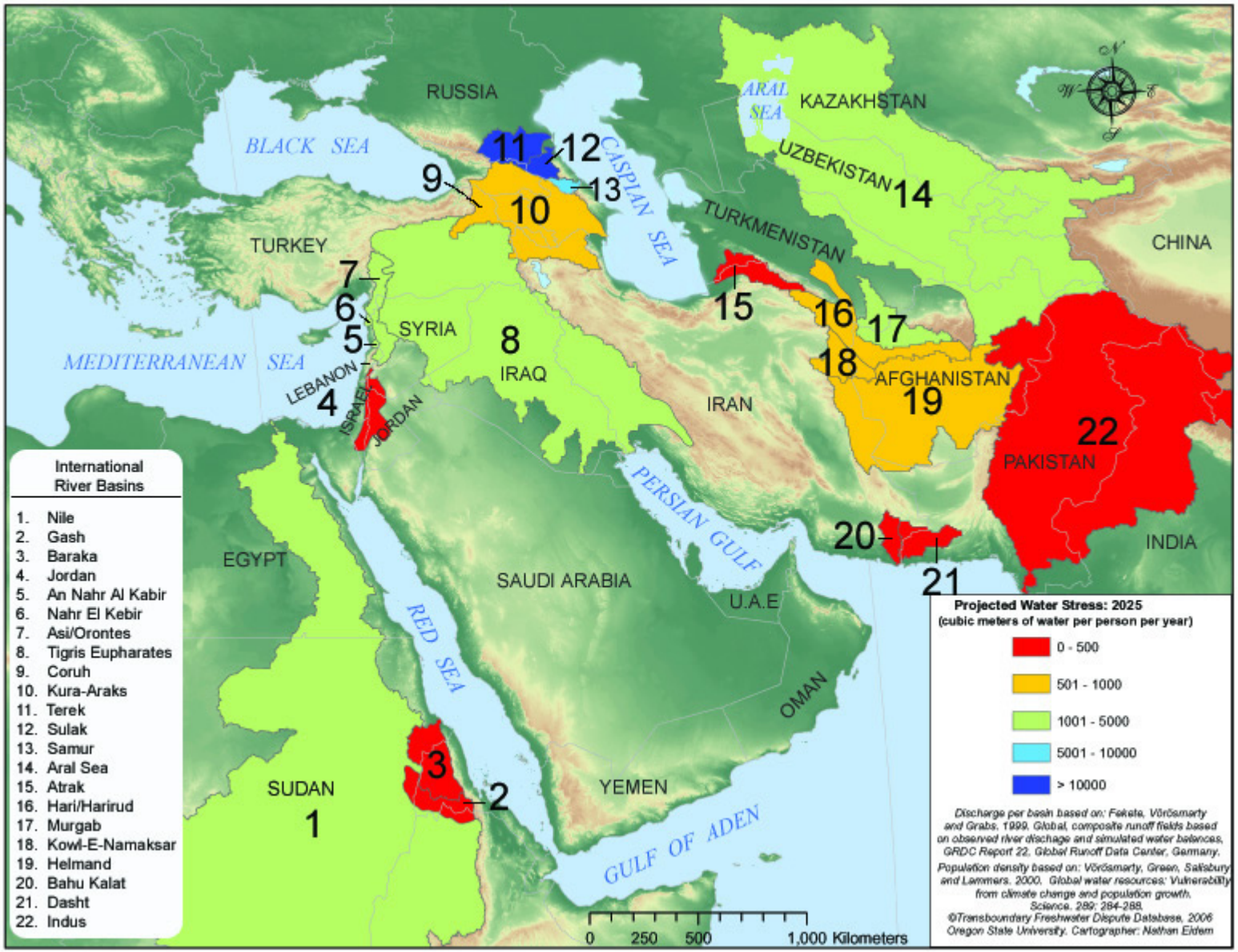
Source: United Nations Economic Commission for Africa (UNECA), Addis Ababa; Global Environment Outlook 2000 (GEO), UNEP, Earthscan, London, 1999; Population Action International.


China's Top Water Issues
The Yellow River
North South Water Diversion
Desertification
N
S
Industrial Pollution
Dams
Yangtze River
Sewage



Legend

- High - consumptive use is greater than 30% of total inflows
- Moderate - consumptive use is between 10% and 30% of total inflows
- Low - consumptive use is less than 10% of total inflows
- Area not assessed


RUSSIA
BLACK SEA
CASPIAN SEA
ARAL SEA
KAZAKHSTAN
UZBEKISTAN
TURKMENISTAN
CHINA
TURKEY
SYRIA
IRAQ
IRAN
AFGHANISTAN
PAKISTAN
INDIA
MEDITERRANEAN SEA
LEBANON
ISRAEL
JORDAN
EGYPT
SAUDI ARABIA
PERSIAN GULF
U.A.E
OMAN
RED SEA
YEMEN
SUDAN
GULF OF ADEN
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
International River Basins
1. Nile
2. Gash
3. Baraka
4. Jordan
5. An Nahr Al Kabir
6. Nahr El Kebir
7. Asi/Orontes
8. Tigris Eupharates
9. Coruh
10. Kura-Araks
11. Terek
12. Sulak
13. Samur
14. Aral Sea
15. Atrak
16. Hari/Harirud
17. Murgab
18. Kowl-E-Namaksar
19. Helmand
20. Bahu Kalat
21. Dasht
22. Indus
0 250 500 1,000 Kilometers
Projected Water Stress: 2025
(cubic meters of water per person per year)
0 - 500
501 - 1000
1001 - 5000
5001 - 10000
> 10000
Discharge per basin based on: Fekete, Vörösmarty and Grabs. 1999. Global, composite runoff fields based on observed river discharge and simulated water balances. GRDC Report 22, Global Runoff Data Center, Germany.
Population density based on: Vörösmarty, Green, Salisbury and Lammers. 2000. Global water resources: Vulnerability from climate change and population growth. Science. 289: 284-288.
©Transboundary Freshwater Dispute Database, 2006
Oregon State University. Cartographer: Nathan Eidem

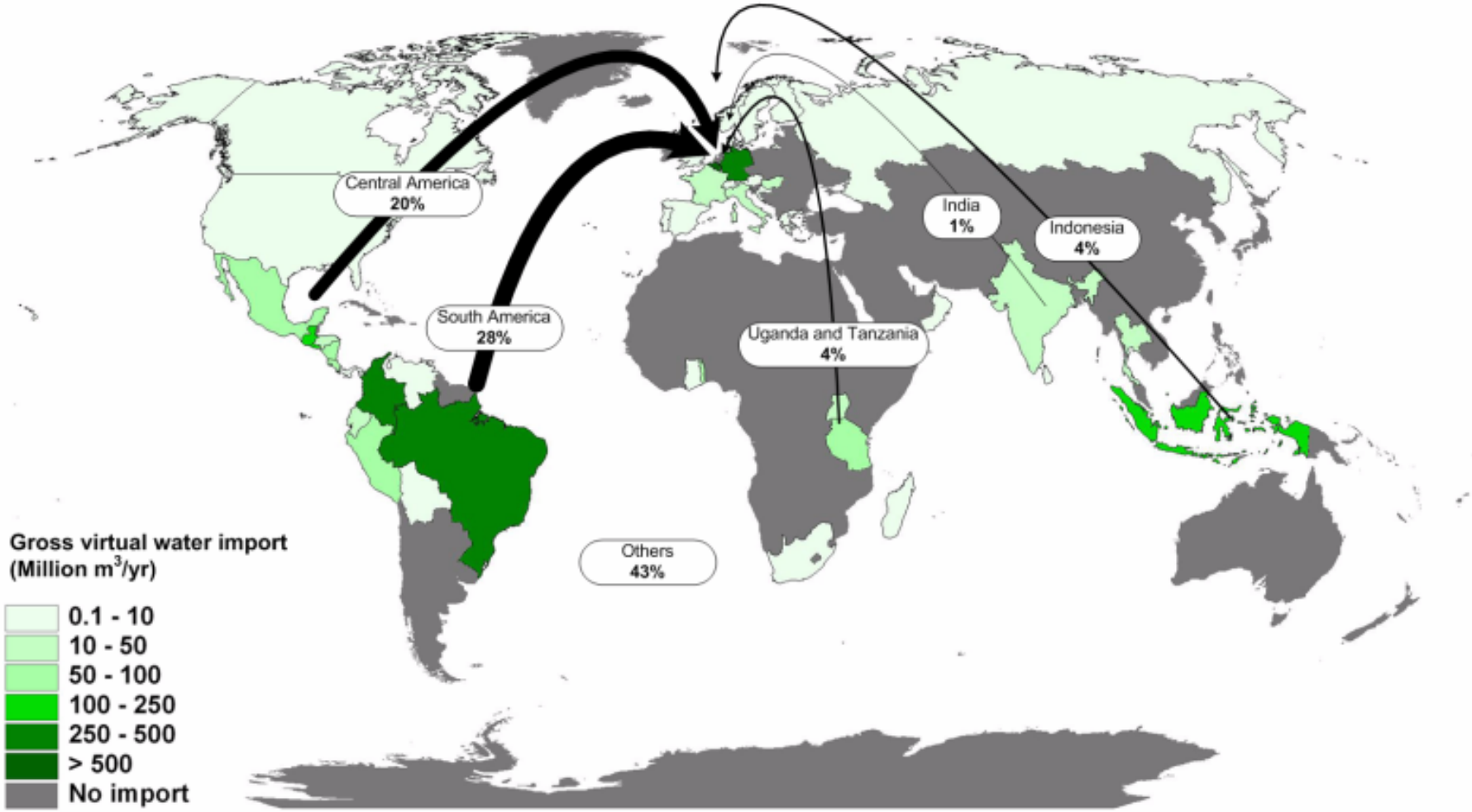

Virtual Water

Average water (in litres) needed to produce a kilo of food[5]

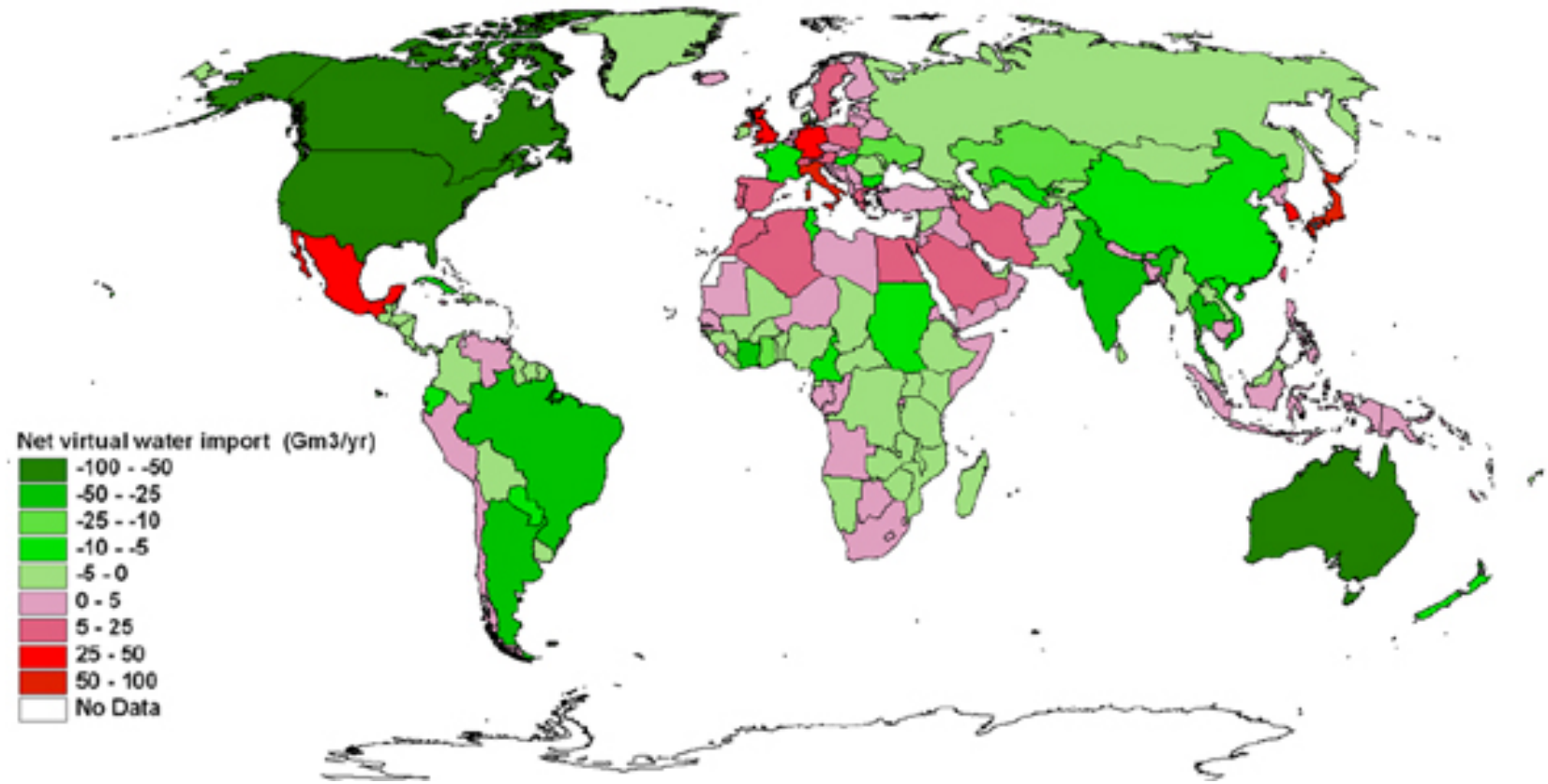
Potatoes	1,000
Maize	1,400
Wheat	1,450
Rice	3,450
Chicken	4,600
Beef	42,500

		Service water (litres / animal / day)	
Animal	Age group	Intensive	Extensive
Beef cattle	Young calves	2	0
	Adult	11	5
Dairy cattle	Calves	0	0
	Heifers	11	4
	Milking cows	22	5
Pigs	Piglet	5	0
	Adult	50	25
	Lactating	125	25

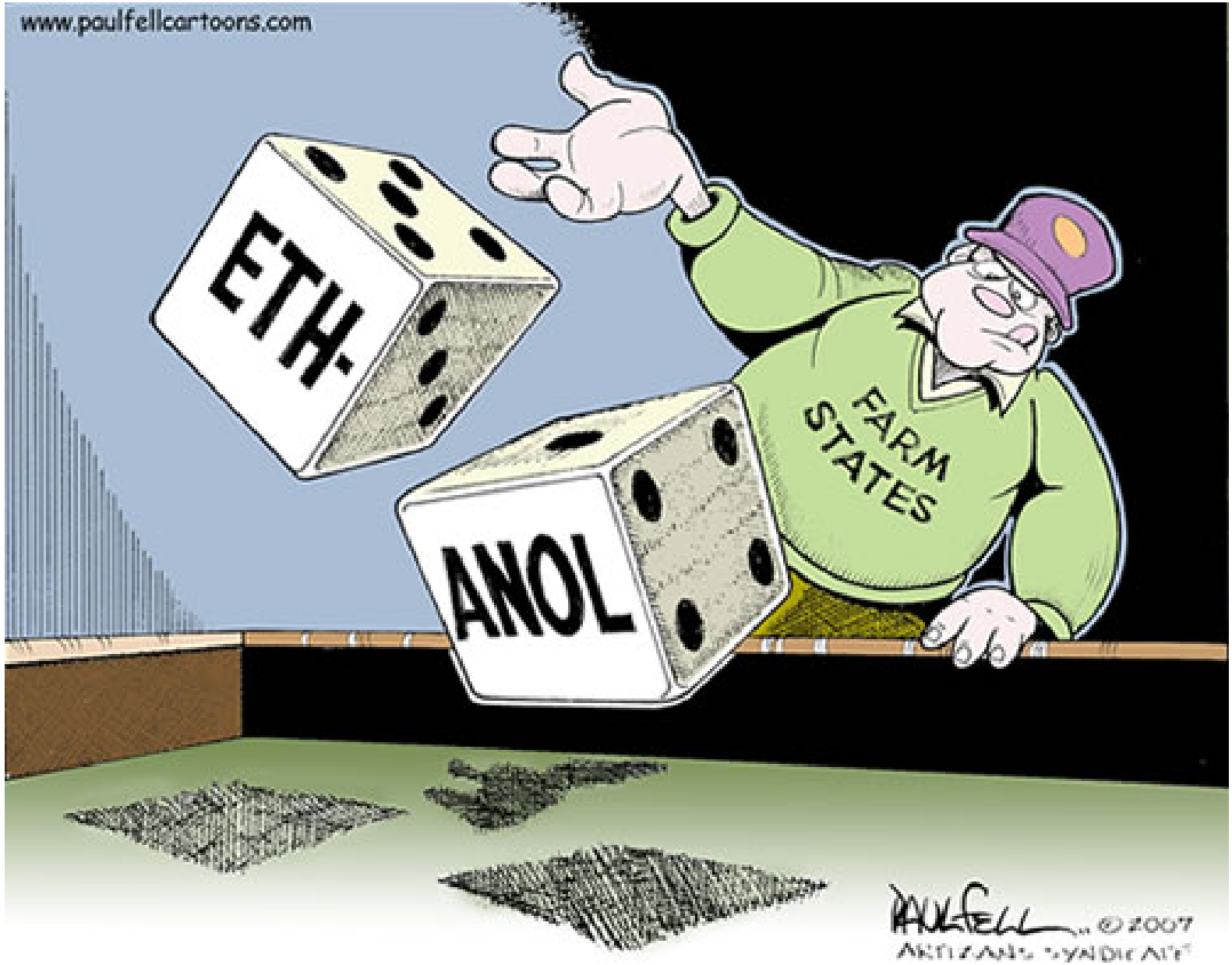
Product	Virtual water content (l)
1 glass of milk (200ml)	75
1 slice of bread (30g)	40
1 potato (100g)	25
1 bag of potato crisps (200g)	185
1 apple (100g)	70
1 egg (40g)	135
1 hamburger (150g)	2400
1 pair of shoes (leather)	8000

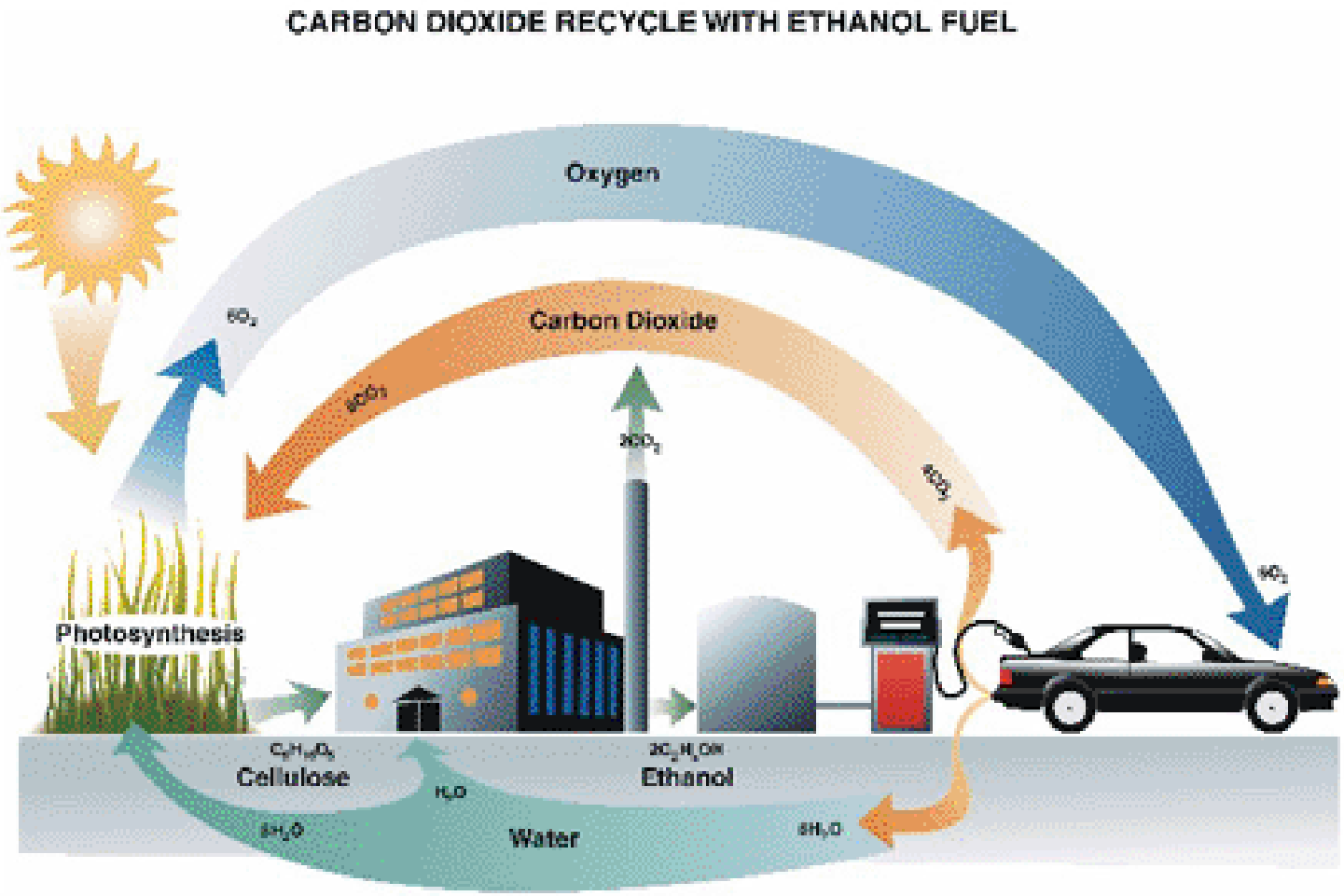

Central America
20%
South America
28%
Others
43%
Uganda and Tanzania
4%
India
1%
Indonesia
4%
Gross virtual water import
(Million m3/yr)
0.1 - 10
10 - 50
50 - 100
100 - 250
250 - 500
> 500
No import


Western Europe
Former Soviet Union
North America
Eastern Europe
Central and South Asia
Middle East
Central America
North Africa
South-east Asia
Central Africa
South America
Oceania
Southern Africa
Net virtual water import (Gm3/yr)
-108
-107
-70
-45
-30
-16
-5
2
13
18
47
150
152
No Data


Net virtual water import (Gm3/yr)
-100 - -50
-50 - -25
-25 - -10
-10 - -5
-5 - 0
0 - 5
5 - 25
25 - 50
50 - 100
No Data


ETHANOL
Ethanol
OIL
OIL
OIL
OIL
OIL
OIL
Illustration by Sean Sheerin

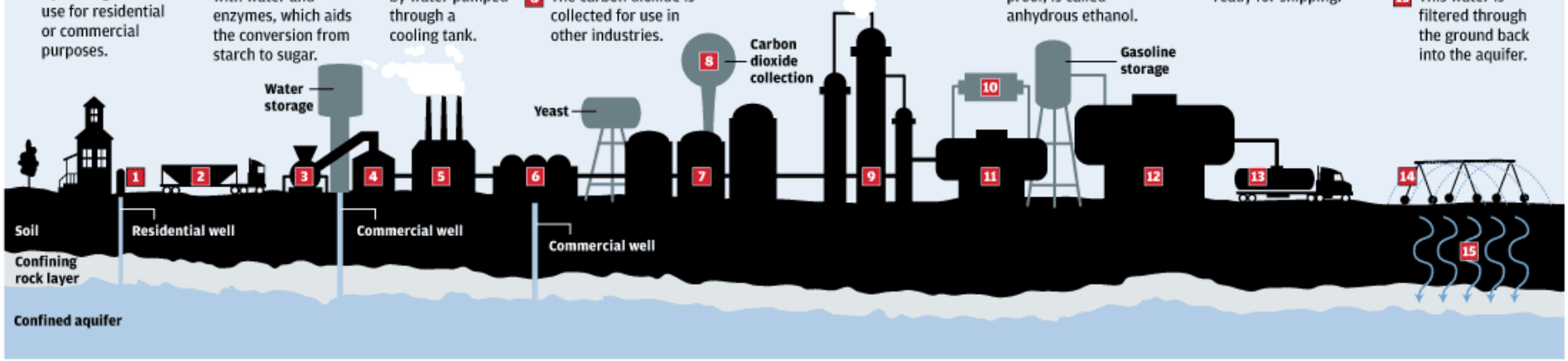

www.paulfellcartoons.com
ETH
ANOL
FARM STATES
PAULFELL ©2007


CARBON DIOXIDE RECYCLE WITH ETHANOL FUEL
Oxygen
Carbon Dioxide
Photosynthesis
Cellulose
Ethanol
Water

WATER IS CRITICAL TO ETHANOL PRODUCTION

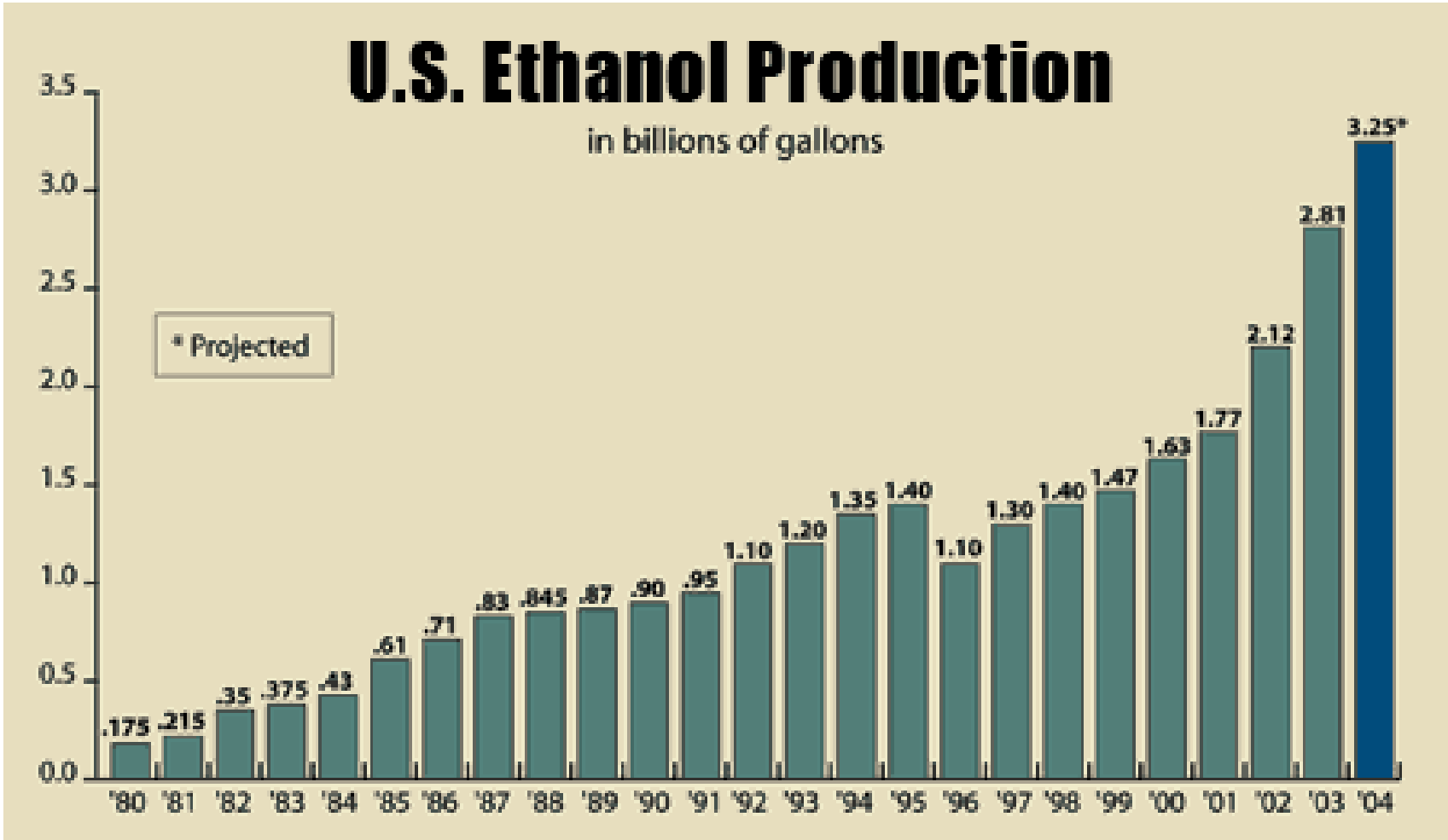
From beginning to end, water is critical in producing ethanol. An ethanol plant like that proposed for Webster County, Mo., using 1.3 million gallons of water each day, consumes about the same amount of water as residents in a town of 13,000 people.

1. Aquifers are vast, underground reservoirs. The water inside has been filtered through the soil and can be tapped by drilling wells for use for residential or commercial purposes.
2. Once the corn arrives at the ethanol plant,
3. it is ground into a fine powder called meal.
4. The meal is mixed with water and enzymes, which aids the conversion from starch to sugar.
5. The liquefied mixture, now called mash, is heated to reduce bacteria levels.
6. It is then cooled by water pumped through a cooling tank.
7. More enzymes and yeast are added to ferment the sugars into ethanol and carbon dioxide. The mash ferments in a series of tanks for about 60 hours.
8. The carbon dioxide is collected for use in other industries.
9. The mash, now called beer, is sent through a series of distillers. The alcohol leaves the final tower at about 96 percent strength.
10. The alcohol passes through a dehydration system where molecular sieves collect the remaining water.
11. The alcohol, now approximately 200 proof, is called anhydrous ethanol.
12. The pure ethanol must be made unfit for human consumption, so 5 percent gasoline is added to the final product.
13. The ethanol is finally ready for shipping.
14. Wastewater from the process is sprayed via a centerpivot irrigation system onto surrounding fields.
15. This water is filtered through the ground back into the aquifer.

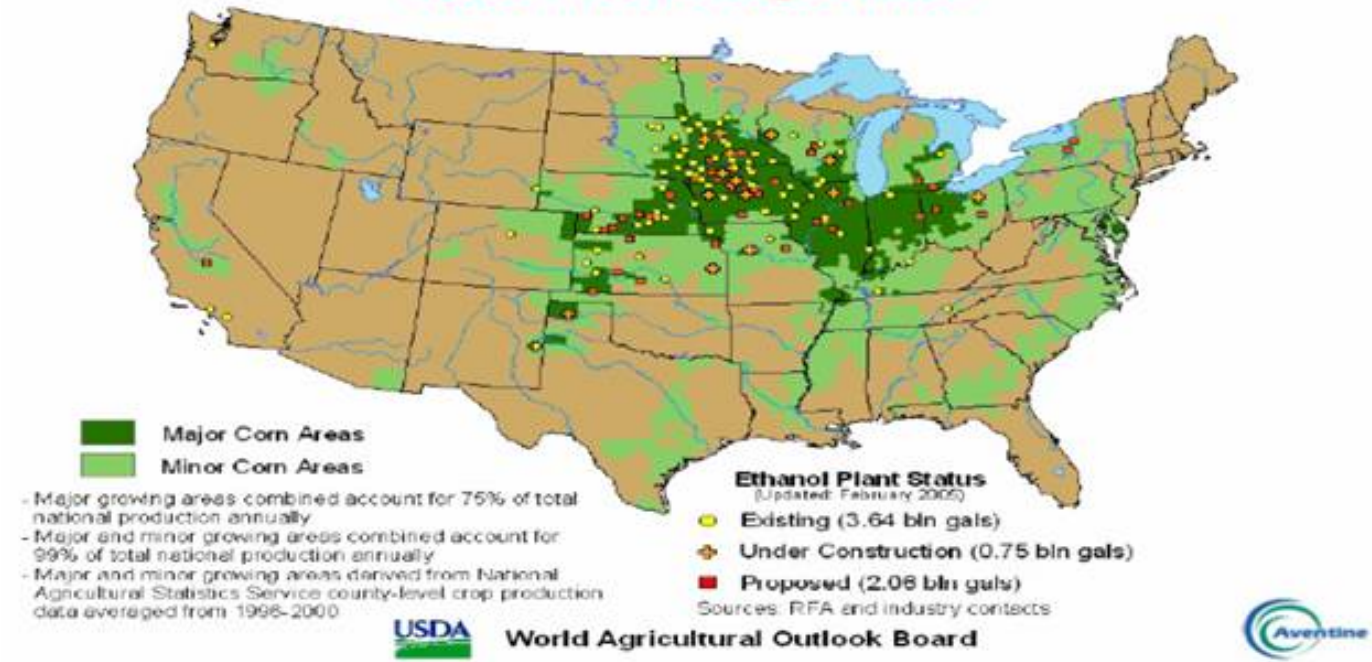


SOURCES: Howstuffworks.com, Midwestethanol.com, Ethanol.org, U.S. Geological Survey, U.S. Environmental Protection Agency

John D. Telford | Post-Dispatch

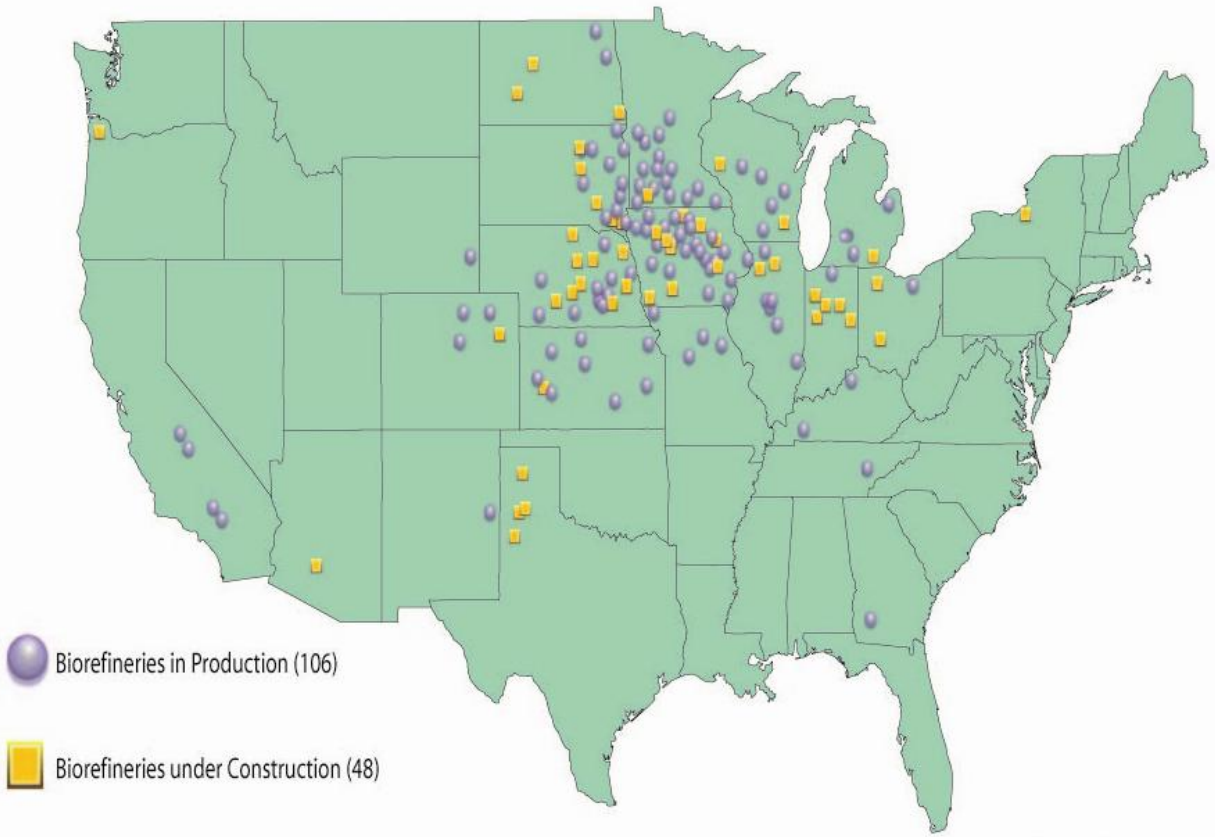

U.S. Ethanol Production
in billions of gallons
* Projected
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
.175
.215
.35
.375
.43
.61
.71
.83
.845
.87
.90
.95
1.10
1.20
1.35
1.40
1.10
1.30
1.40
1.47
1.63
1.77
2.12
2.81
3.25*
'80 '81 '82 '83 '84 '85 '86 '87 '88 '89 '90 '91 '92 '93 '94 '95 '96 '97 '98 '99 '00 '01 '02 '03 '04

Ethanol Plant Locations Relative to Major Corn Producing Areas

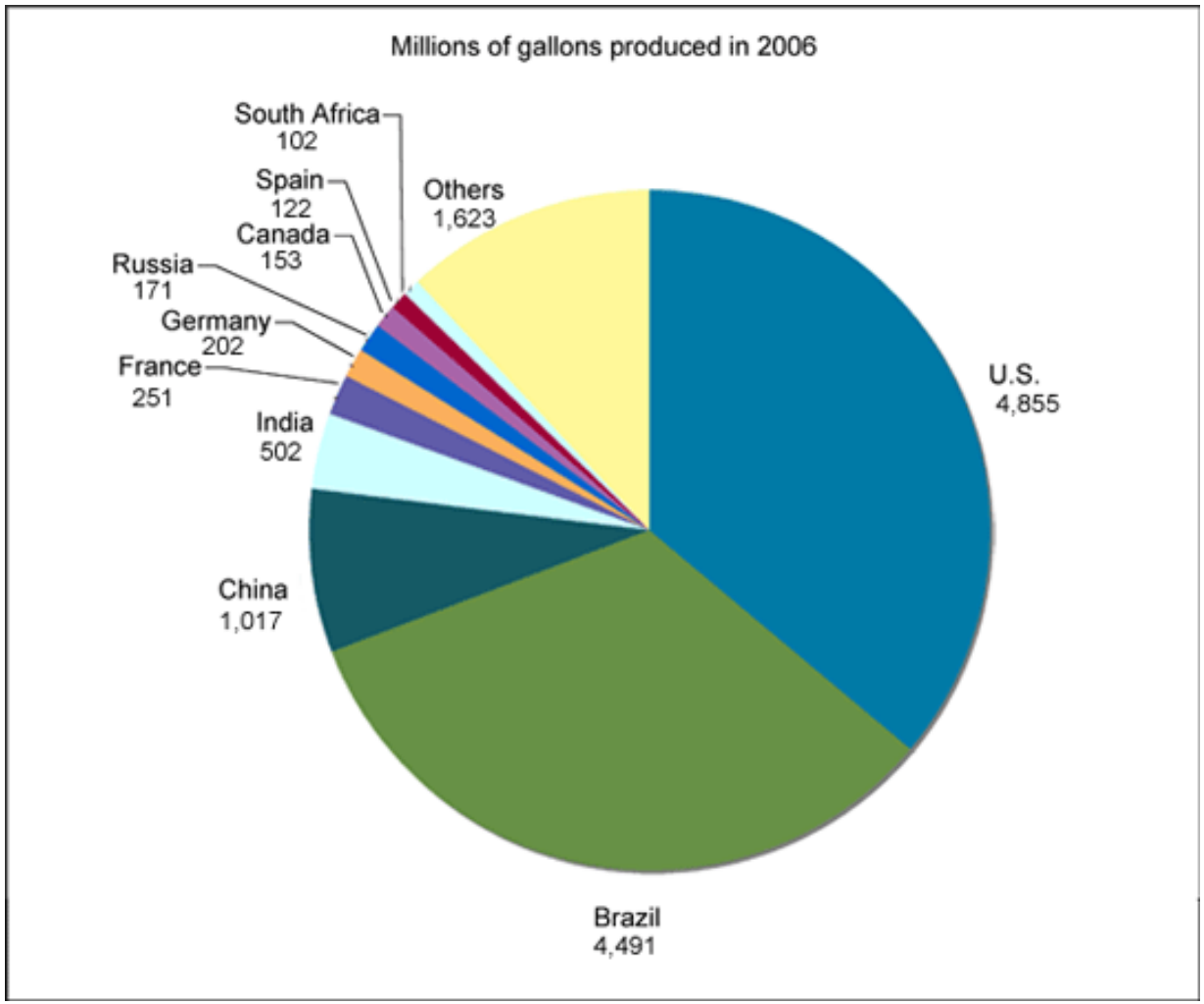


Source: Citigroup Investment Research and U.S. Department of Agriculture

U.S. Ethanol Biorefinery Locations



Source: Renewable Fuels Association


Millions of gallons produced in 2006
South Africa
102
Spain
122
Canada
153
Russia
171
Germany
202
France
251
India
502
China
1,017
Brazil
4,491
U.S.
4,855
Others
1,623