Por lo demás, todo lo que atañe el agua es poético y nunca deja de inquietarnos

La jonction, in: *Atlante*, Jorge Luis Borges, 1984

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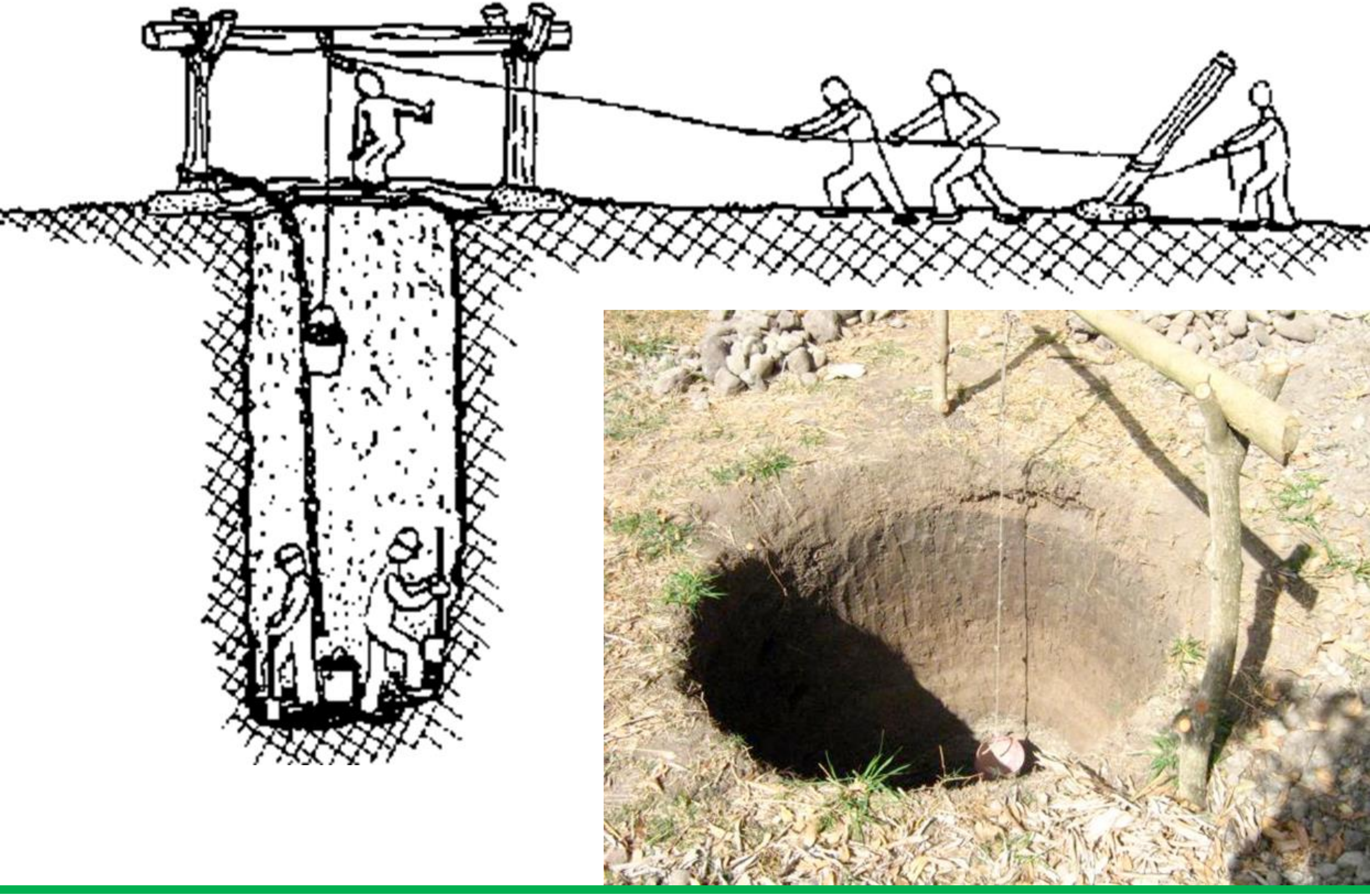
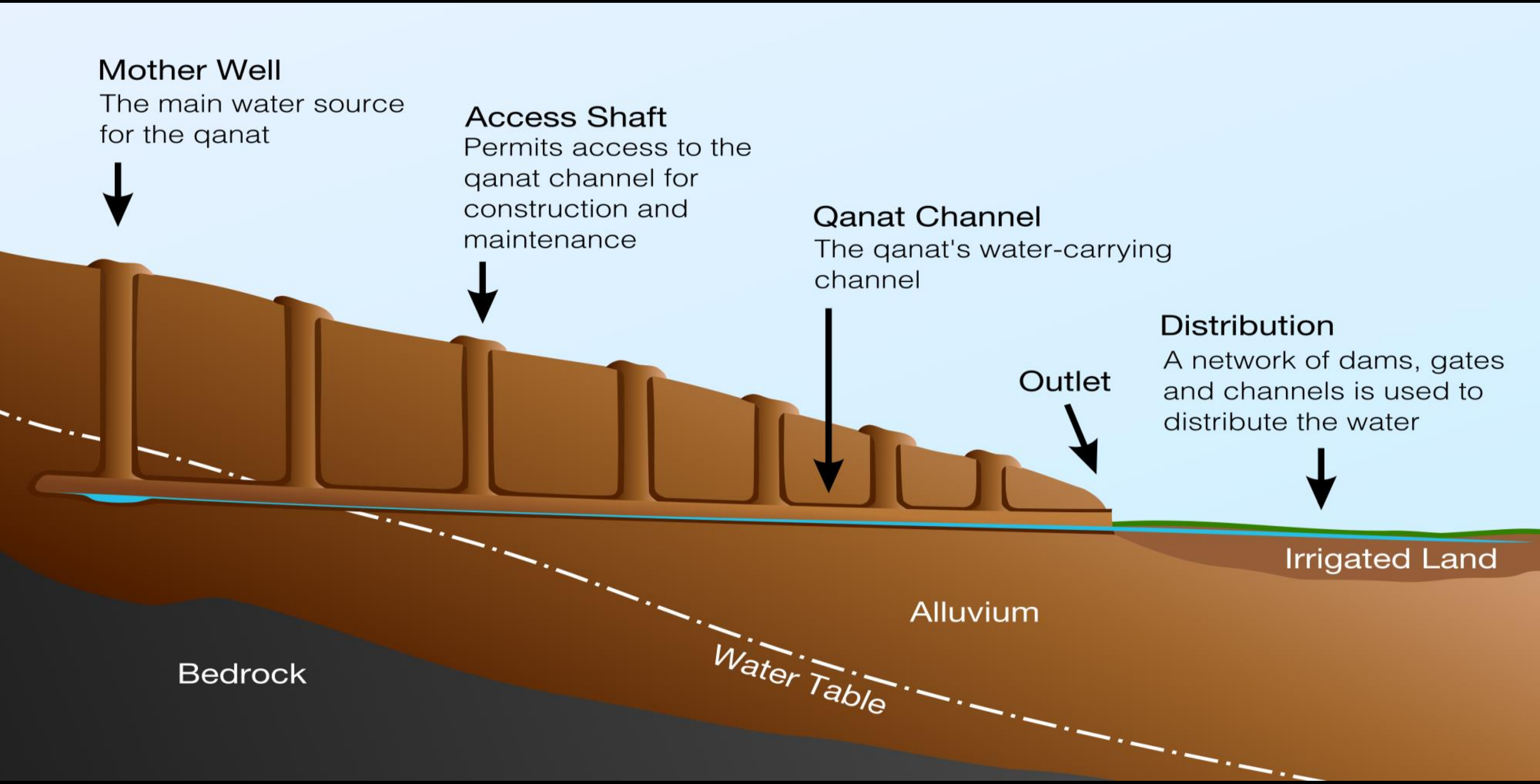
POLITECNICO DI MILANO

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

CoNISMa Consorzio Nazionale Interuniversitario per le Scienze del Mare

ISTITUTO LOMBARDO ACCADEMIA DI SCIENZE E LETTERE




Mother Well
The main water source for the qanat
Access Shaft
Permits access to the qanat channel for construction and maintenance
Qanat Channel
The qanat's water-carrying channel
Outlet
Distribution
A network of dams, gates and channels is used to distribute the water
Irrigated Land
Alluvium
Bedrock
Water Table

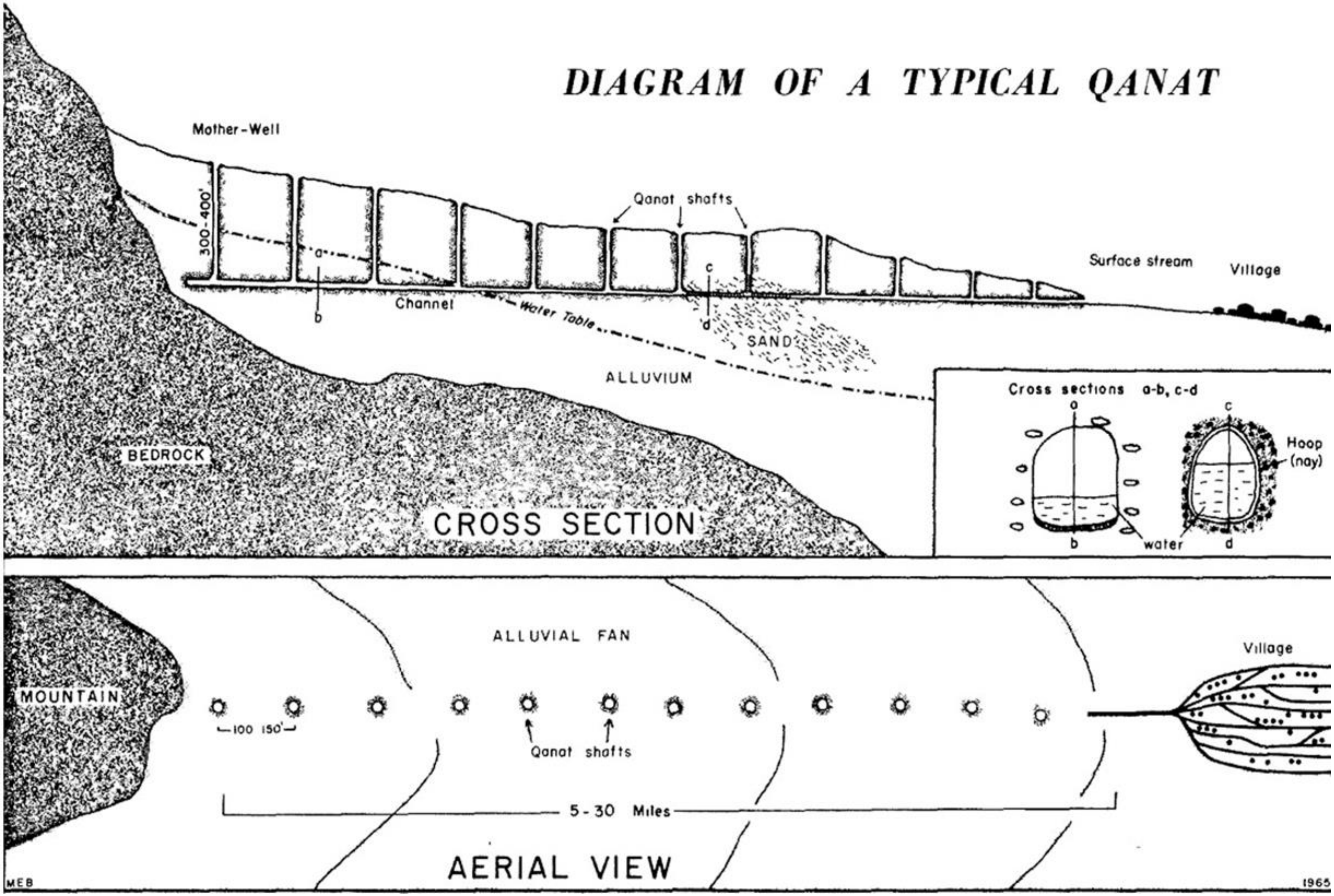


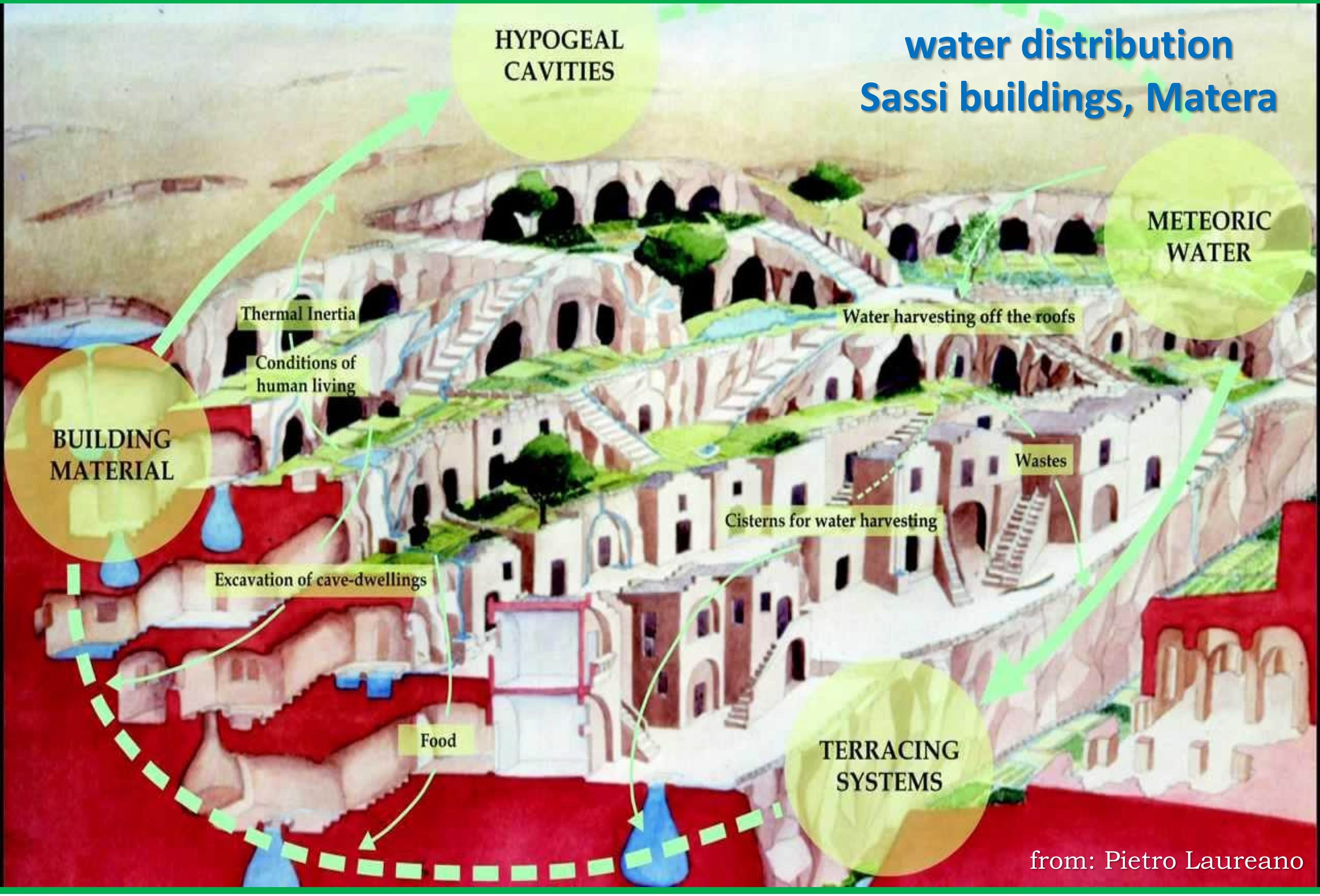
DIAGRAM OF A TYPICAL QANAT
Mother-Well
300-400'
Qanat shafts
a
b
c
d
Channel
Water Table
Surface stream
Village
SAND
ALLUVIUM
BEDROCK
CROSS SECTION
Cross sections a-b, c-d
Hoop (nay)
water
ALLUVIAL FAN
MOUNTAIN
100 150'
Qanat shafts
Village
5-30 Miles
AERIAL VIEW
MEB
1965

Anshan qanat (Iran) seen from the air (estimated 1000 BC)

water distribution in a sub-saharian oasis
khettara eco museum, morocco

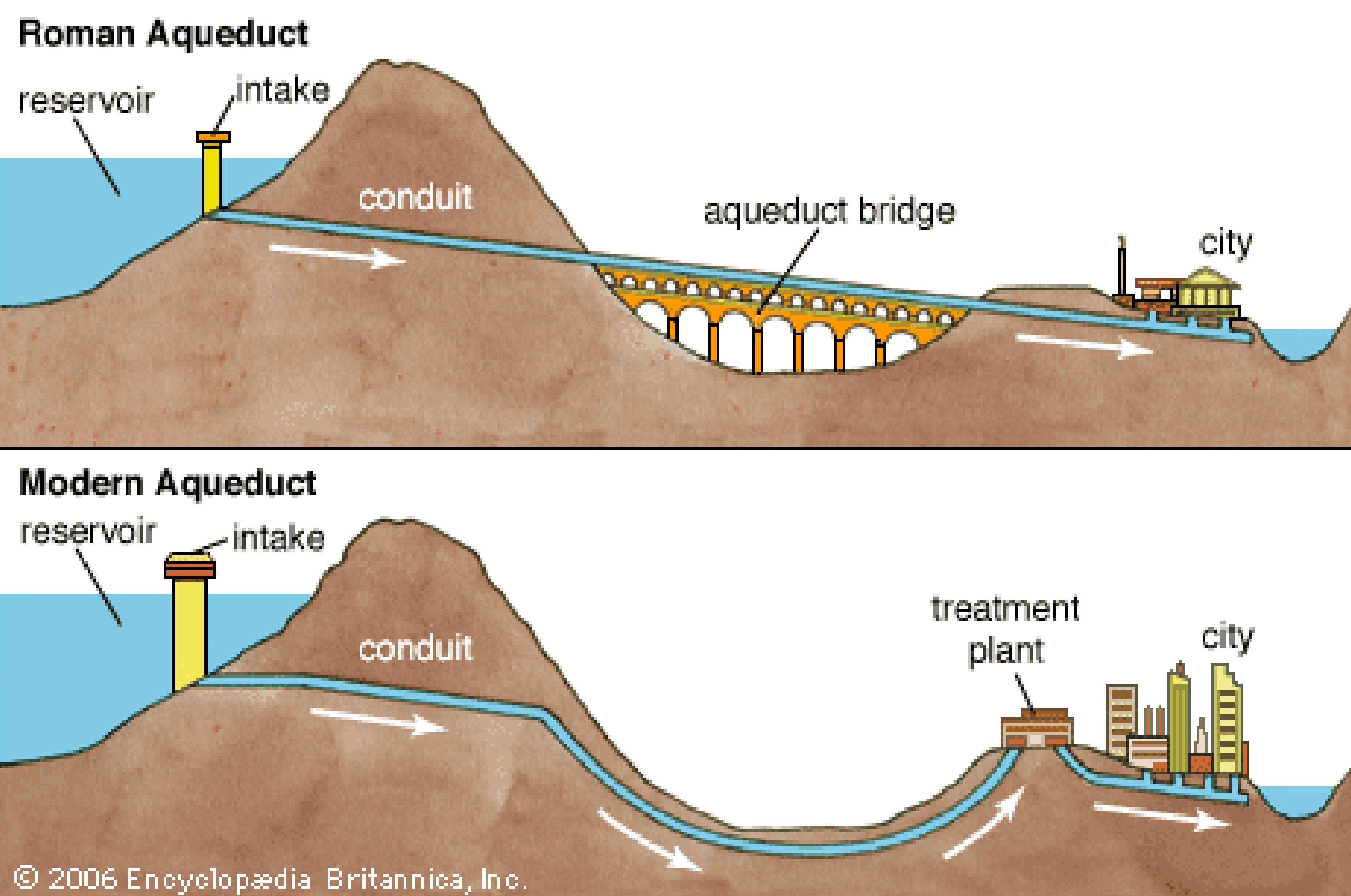
Pietro Laureano

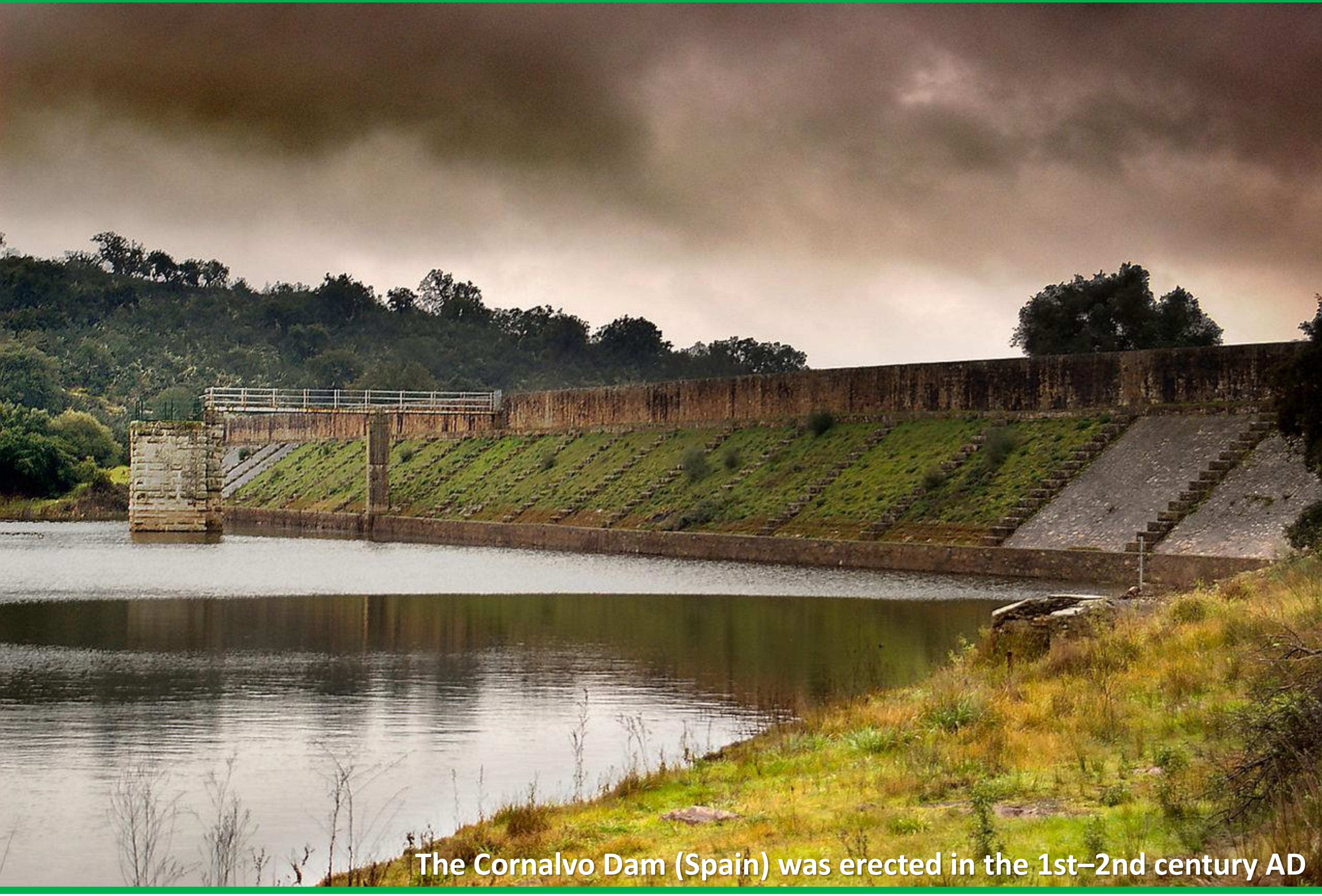
water distribution Sassi buildings, Matera



from: Pietro Laureano


Candido
The Segovia Aqueduct (Spain)
erected in the 1st century AC


Roman Aqueduct
reservoir
intake
conduit
aqueduct bridge
city
Modern Aqueduct
reservoir
intake
conduit
treatment plant
city
© 2006 Encyclopædia Britannica, Inc.


The Cornalvo Dam (Spain) was erected in the 1st–2nd century AD

water availability and consumption

Although the Earth has **35 million cubic kilometres of freshwater**, it is unevenly distributed across the planet or is located in areas that are expensive to tap or access: 70% is trapped in the form of ice or snow, or deep underground.

The remaining **11 million cubic kilometres** of readily **available freshwater** reserves are under increasing stress: human freshwater usage has tripled in the past 50 years alone.

Today, there are roughly **700 million people** across **43 countries** living in regions with **severe water scarcity**

water availability and consumption, 2

Water is a unique natural resource with the capacity to become **renewable**: water that has been “consumed” is not lost to the hydrologic cycle or to its future use – it is simply **recycled by natural systems**.

Therefore **consumptive uses** of water only refer to uses of water that make water unavailable for **immediate** or **short-term reuse** (evaporated, transpired, incorporated to crops or consumed).

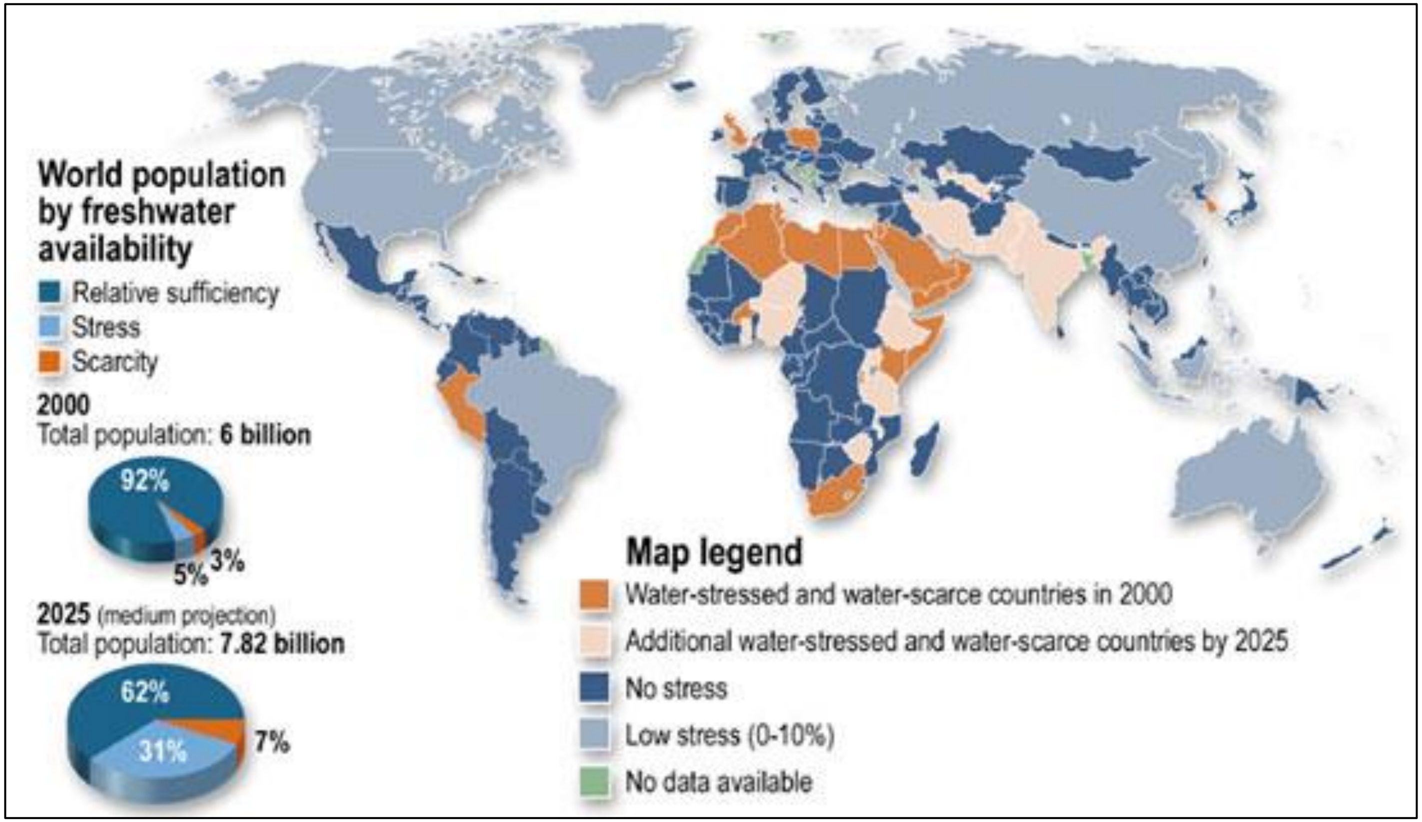
While water can eventually be recovered for future use and even desalinated, population growth, urbanization and modernization **demand** that policy-makers be prepared to respond to inextricably linked and time-sensitive water and **food** and **energy** **security** concerns.

stress e **scarsità**

water stress = freshwater availability **< 1,700 m³/year per-capita**
water scarcity = freshwater availability **< 1,000 m³/year per-capita**
absolute water scarcity = ……………….. … ….. ….. **< 500 m³/year per-capita**

in next future **stress** & **scarcity** will spread around the workd

PHYSIACAL WATER SCARCITY

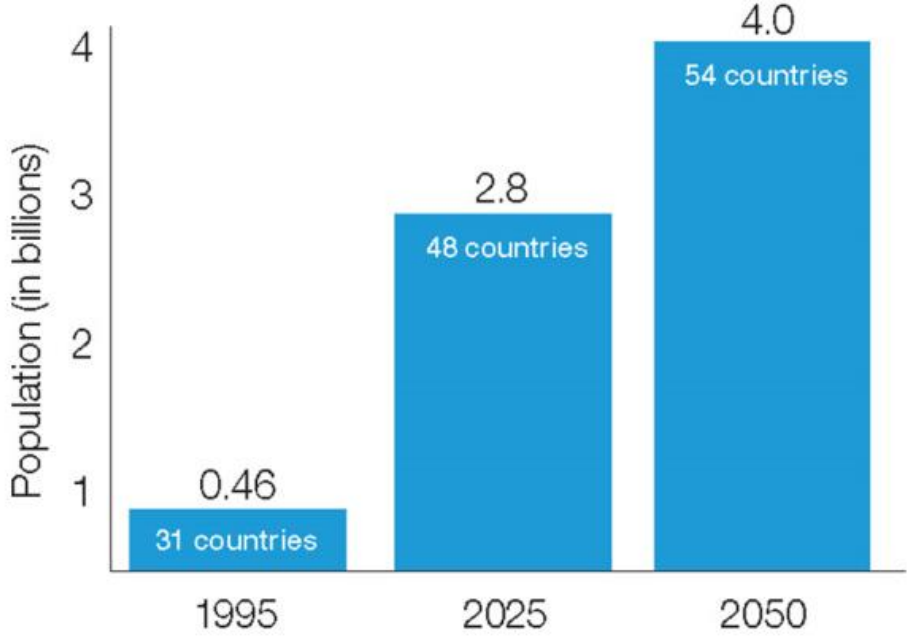


Following Population Action International, **more than 2.8 billion people in 48 countries** will face water scarcity scenarios starting from year 2025 as resulting from matching the projection of world population by United Nations with avalibale freshwater resources,

40 countries out of 48 are in Western Asia, North Africa or Sub-Saharian Africa

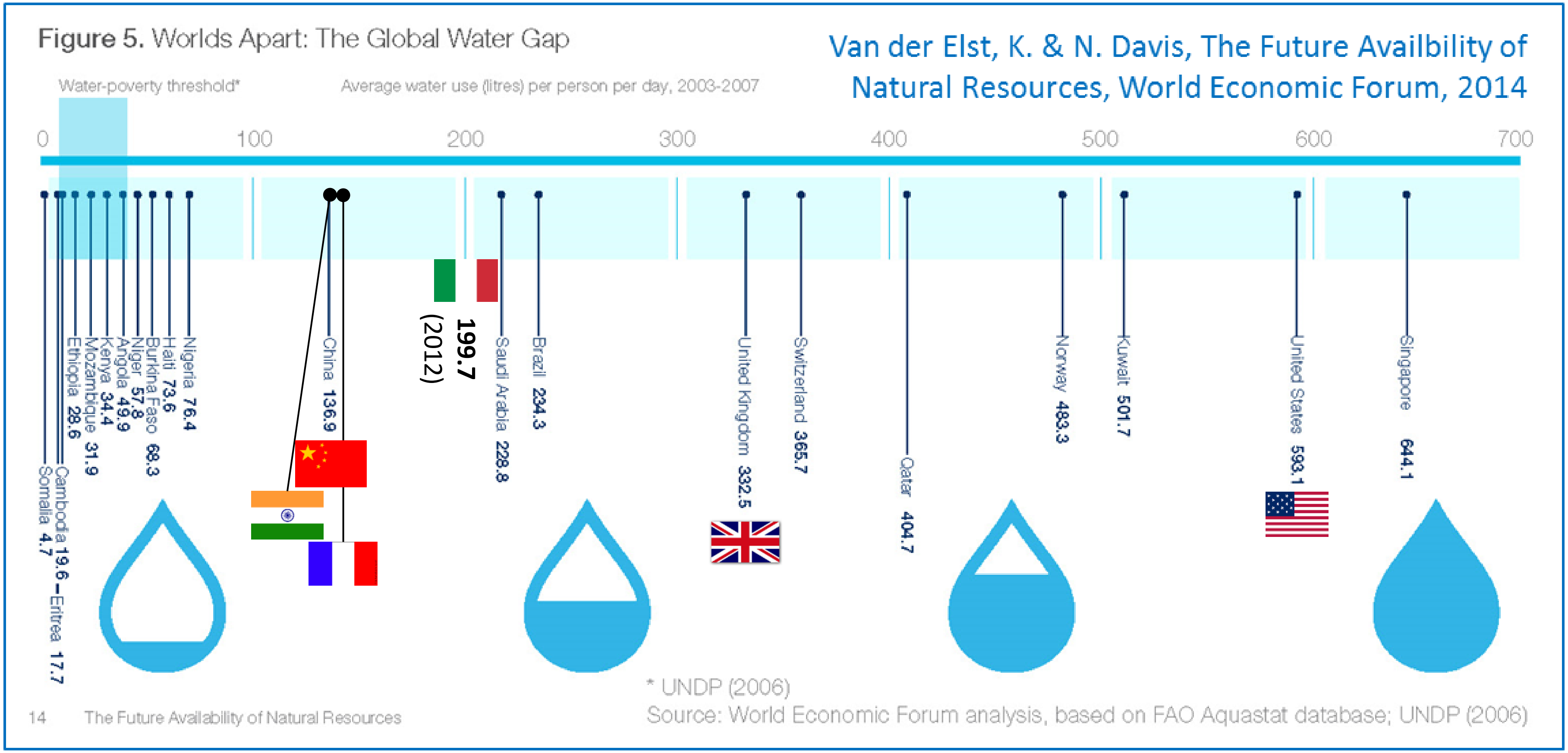
In year 2050, water scarcity scenarios could involve 54 countries, where 40% of world population will live

Figure 5: Water Scarcity and Stress
Population in water-scarce and water-stress countries, 1995-2050



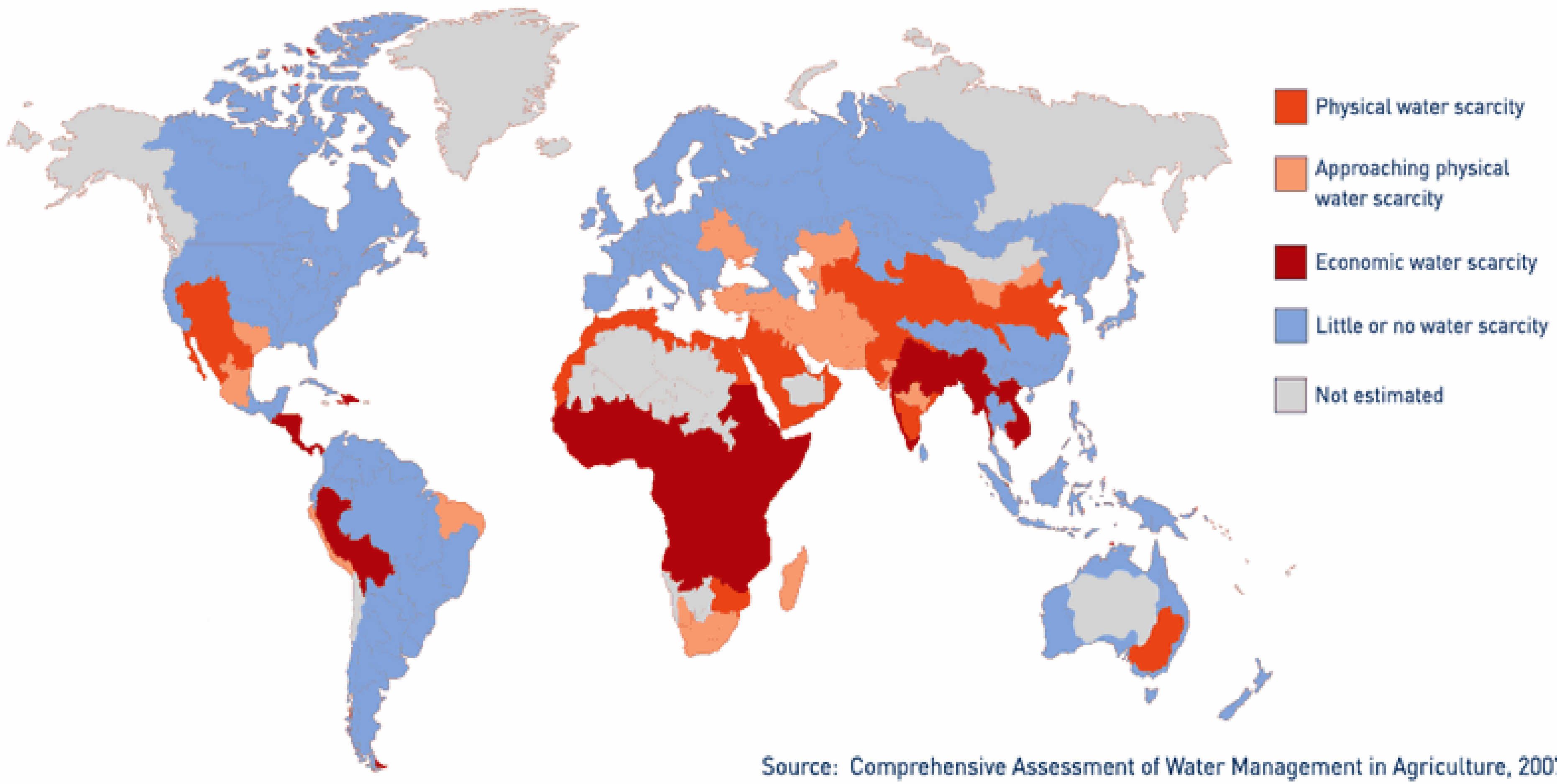
Vital Water Graphics, UNEP. http://www.unep.org/dewa/vitalwater/article141.html

Focusing on absolute freshwater availability is a **weapon of mass distraction**, because the major issue is not only geografic distribution, but **social distribution** too within a given geografic unite



Current tenency of world population to increse networking amplifies people consciousness of inequality of distribution, so pushing towards ovecoming inequalities

WATER SCARSITY (physical and economic)



Source: Comprehensive Assessment of Water Management in Agriculture, 2007

water and food

water and energy

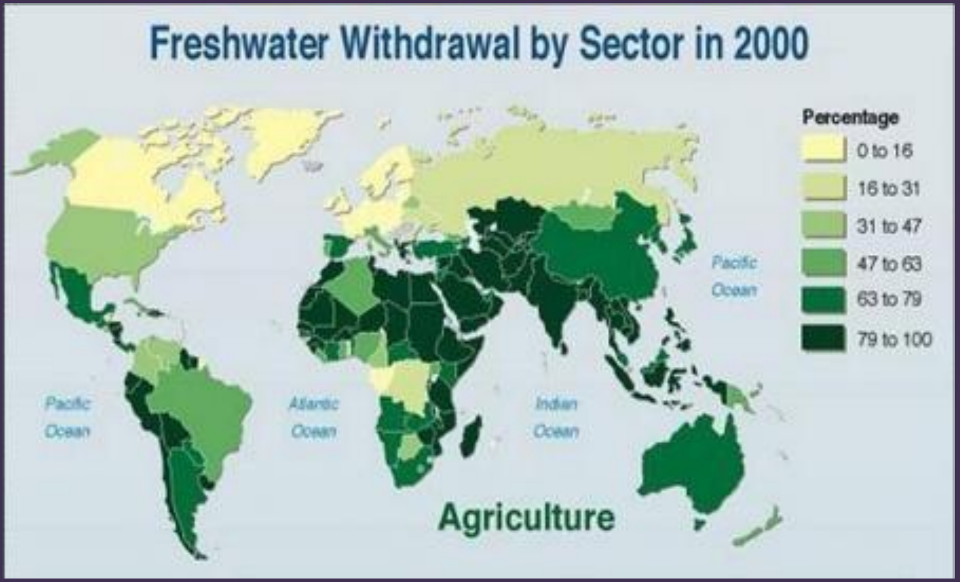
water and climate

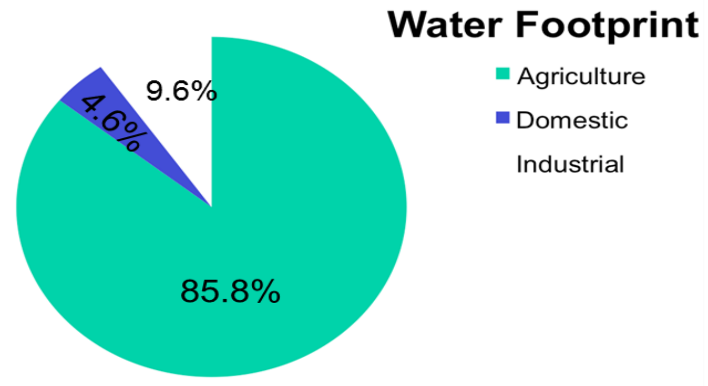
the role of water towers

water and the city

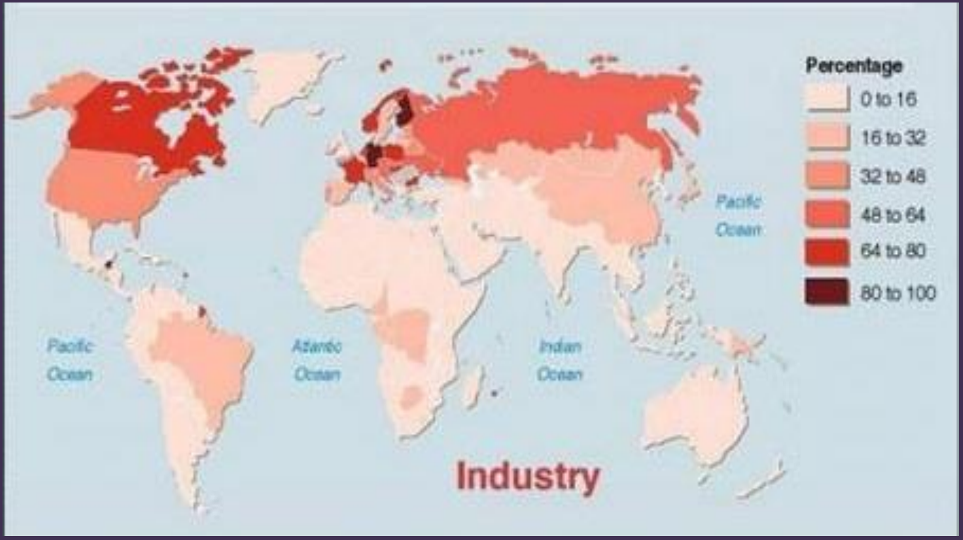

water and food

Major water use is associated with food production





(Chapagain and Hoekstra, 2004)



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

Virtual Water

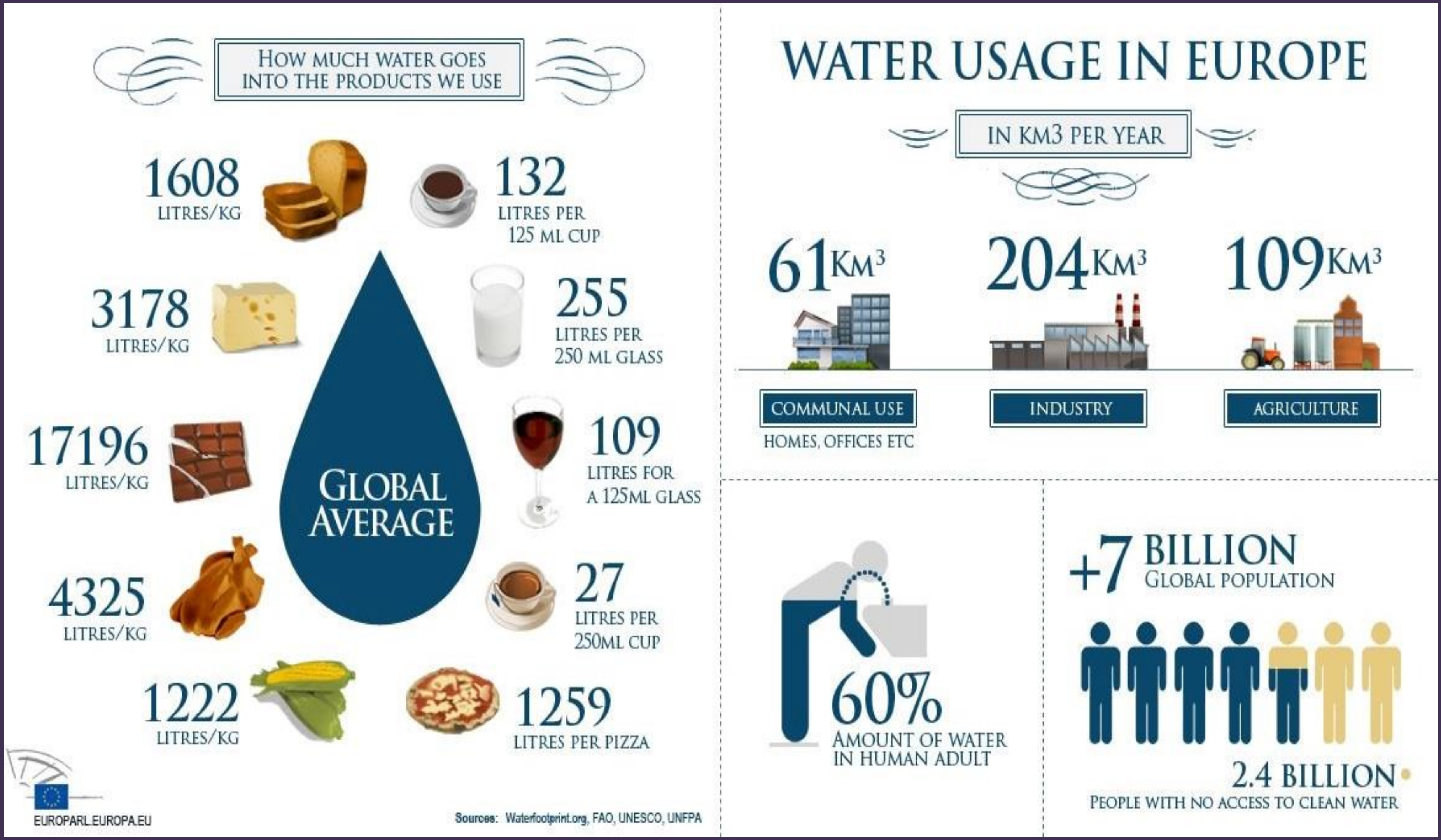
The **water footprint** is the amount of water you use in and around your home throughout the day

It includes the water you use directly (i.e., from a tap) and the water that is used to produce the food you eat, the products you buy, the energy you consume and even the water you save when you recycle

You may not drink, feel or see this virtual water, but it makes up the majority of your water footprint

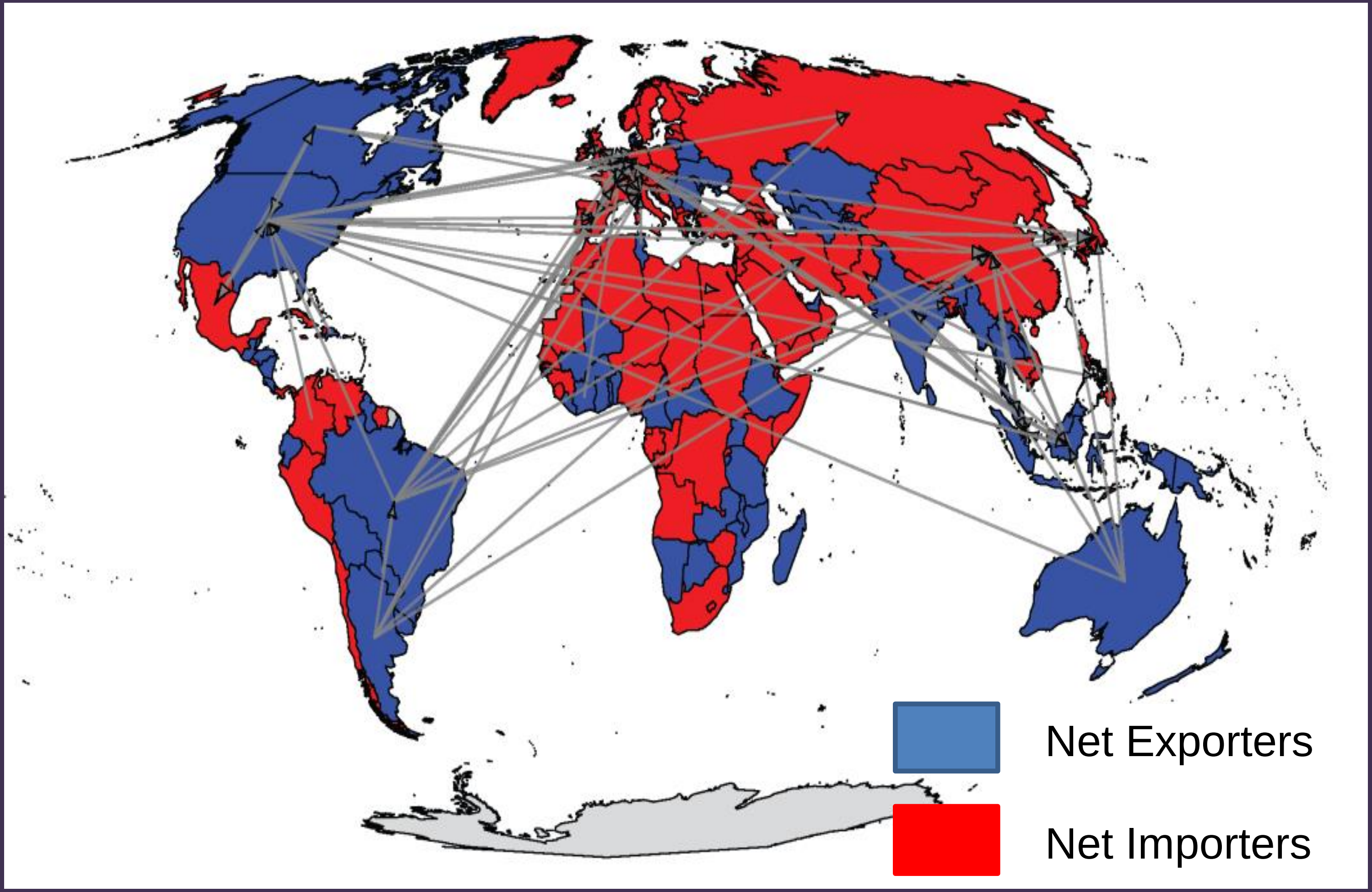
(Allan, 1998)

Virtual Water, 2



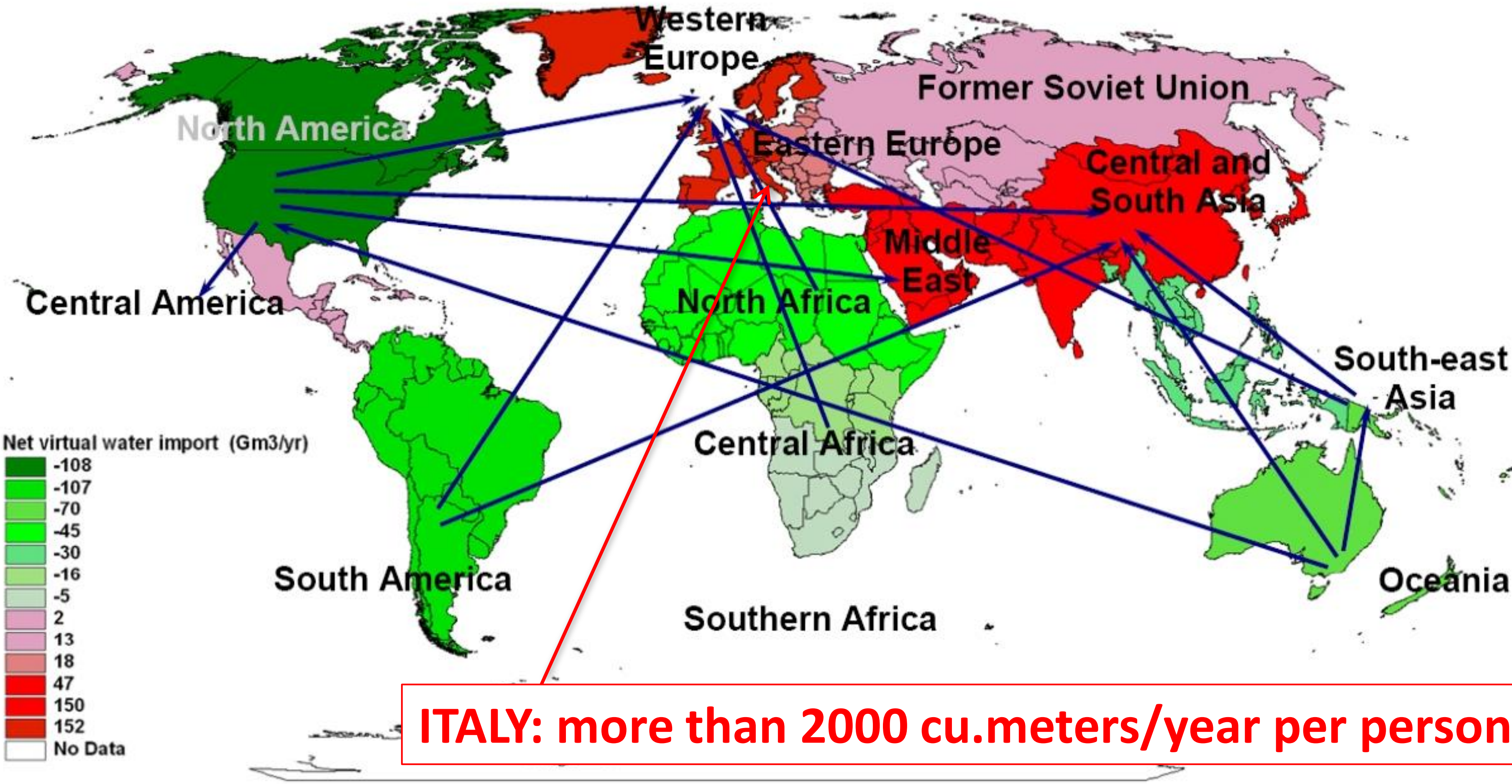
Global Water Trade

virtual water "fluxes" associated with import-export of goods



Suweis et al., 2011; Carr et al., 2013

NET IMPORT OF VIRTUAL WATER (Giga m^3 / YEAR)



ITALY: more than 2000 cu.meters/year per person

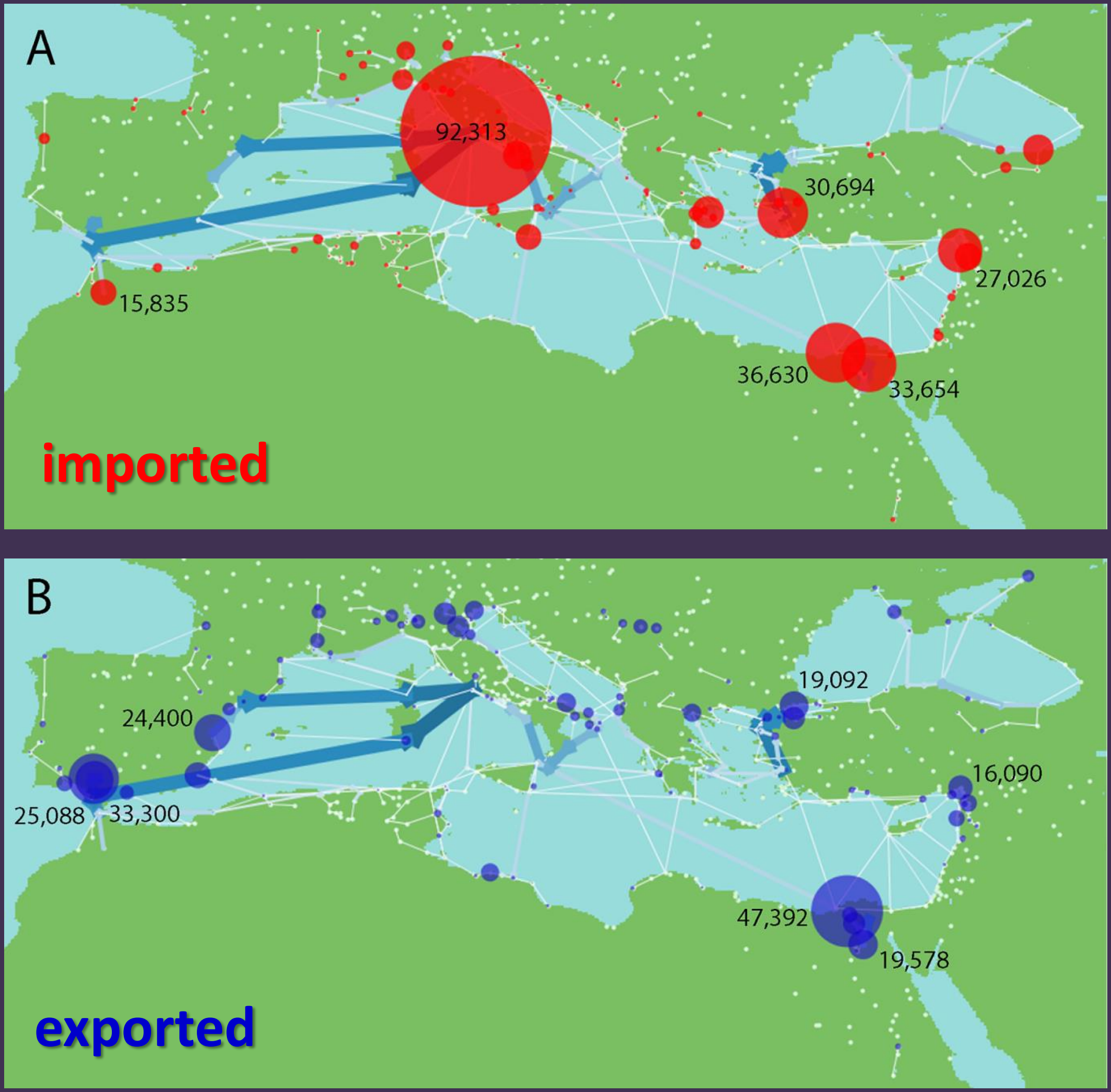
i.e. ITALY: 168 mm/year of rain over total country area
358 mm/year of rain over total arable country area

Virtual water imports and exports (tonne grain / year).

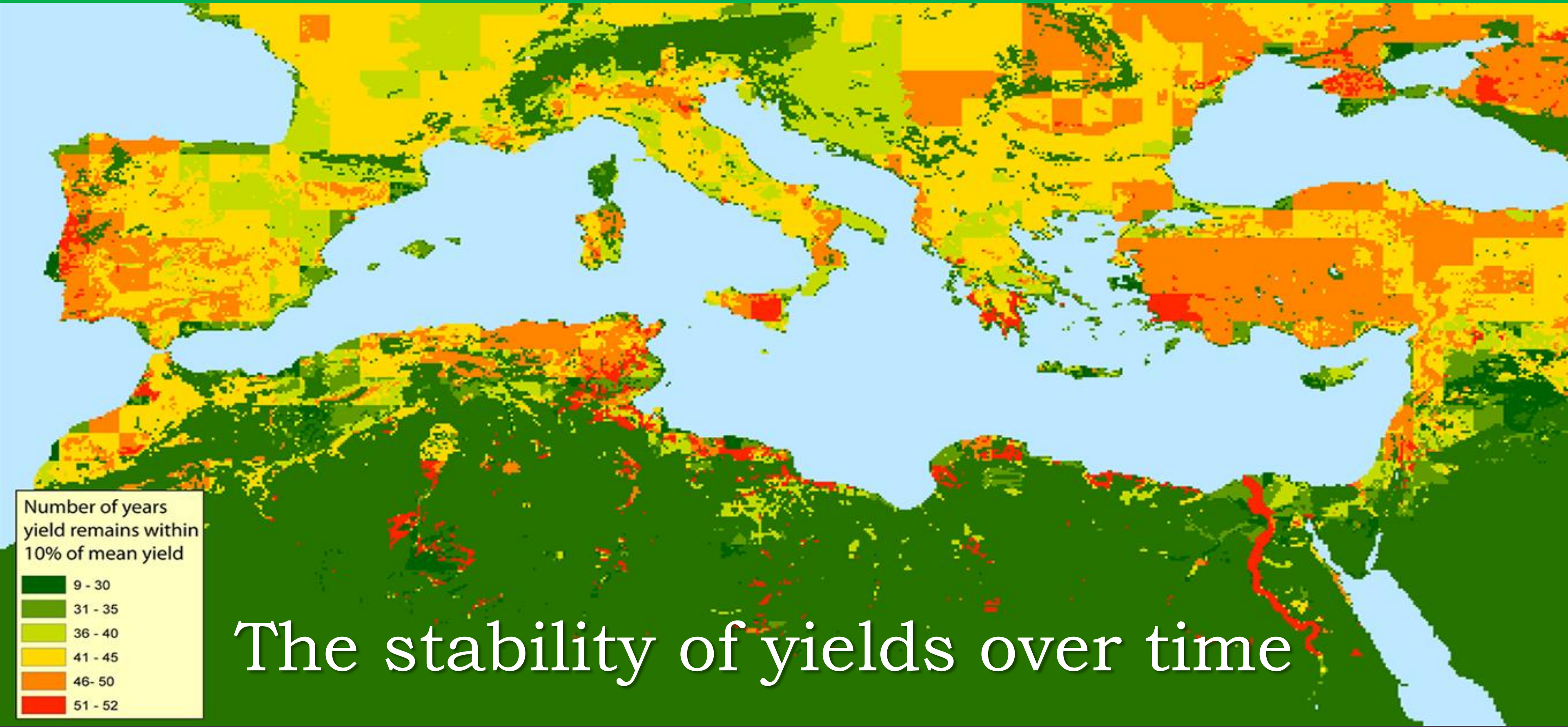
Relative amount of WT from each node: size of the nodes.

The associated numbers show the average VW imported or exported each year. The edge colour and thickness indicates the relative volume of VW flow between nodes.

The largest flows are between Spain and Italy, locally within Egypt, from south-eastern Italy to western Italy and along the Aegean coast of Turkey. Rome is by far the largest importer of VW, followed by Alexandria and Memphis in Egypt, Ephesus on the west coast of Turkey, Antioch in south-eastern Turkey and Corinth in Greece



Dermody, B.J., R. P. H. van Beek, , E. Meeks, , K. Klein Goldewijk, , W. Scheidel, Y. van der Velde, M. F. P. Bierkens, M. J. Wassen, and S. C. Dekker, A virtual water network of the Roman world, *Hydrol. Earth Syst. Sci.*, 18, 5025–5040, 2014.



The map shows in how many years the total annual yield in each cell remains within 10% of the average yield for the same cell calculated over 52 years of climate forcing. In the Nile Valley, yields remain within 10% of the average yield in all years, meaning that yields are exceptionally stable. Regions of northern Spain and northern France are relatively unstable with yields dropping below 10% in at least 40 out of 52 years.

Dermody, B.J., R. P. H. van Beek, , E. Meeks, , K. Klein Goldewijk, , W. Scheidel, Y. van der Velde, M. F. P. Bierkens, M. J. Wassen, and S. C. Dekker, A virtual water network of the Roman world, *Hydrol. Earth Syst. Sci.*, 18, 5025–5040, 2014.

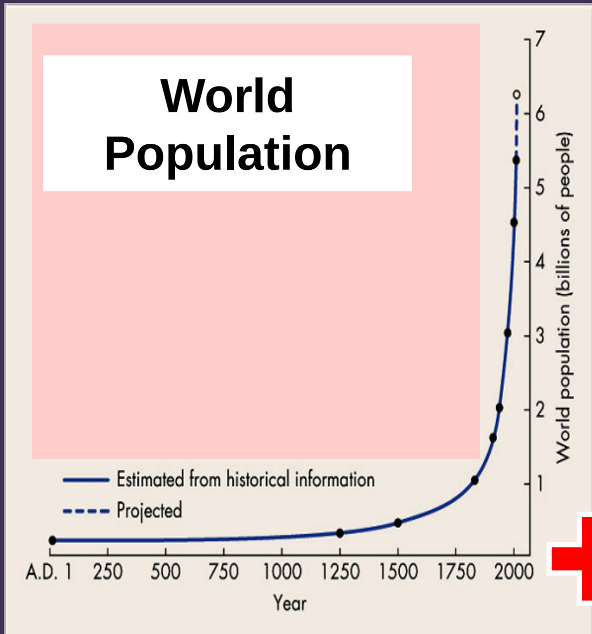
“Panis et Circenses”

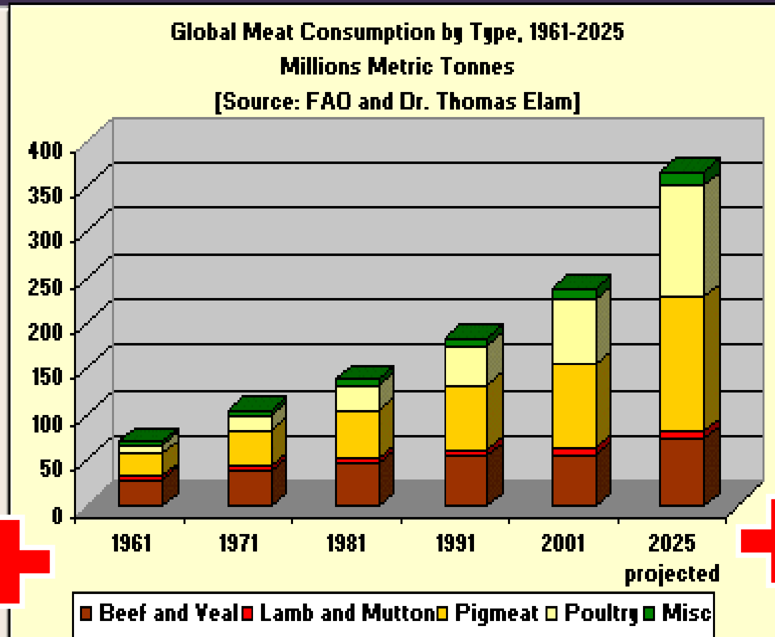
- How could the Roman empire persist so long, under pressures of:
  - urbanisation
  - climate change (temperature)
- High resilience to climate variability
  - combining rainfed with irrigated agriculture
  - flexible trade network

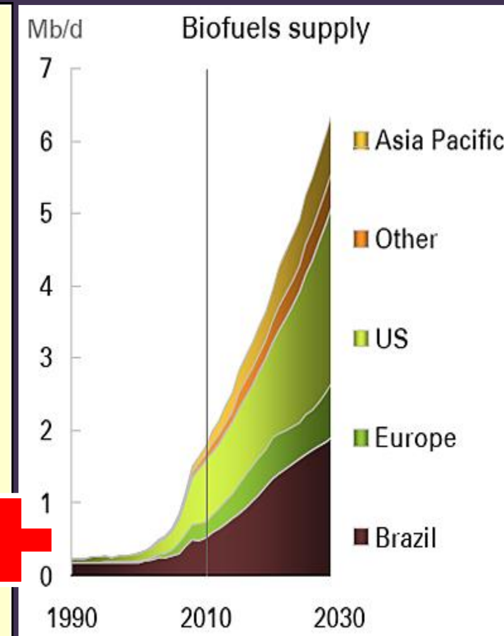
Virtual Water Trade (VWT) was a fundamental factor for **stability** of Roman Empire across several centuries, because they develoed an efficient virtual water network trade, capable of facing inter-annual climate variability in a large geographic area

Advanced **Irrigation Methods** e the efficient **virtual water trade network** were key factors of Empire **resilience**

Conversely, **virtual water trade** incresed **urbanisation** towards approching sustainable limits of growth in trems of water availability. This increased water trade costs, so **diminishing long term climate resilience**







Competitive Scenario of Water Resources exploitment for Food production versus Energy production?

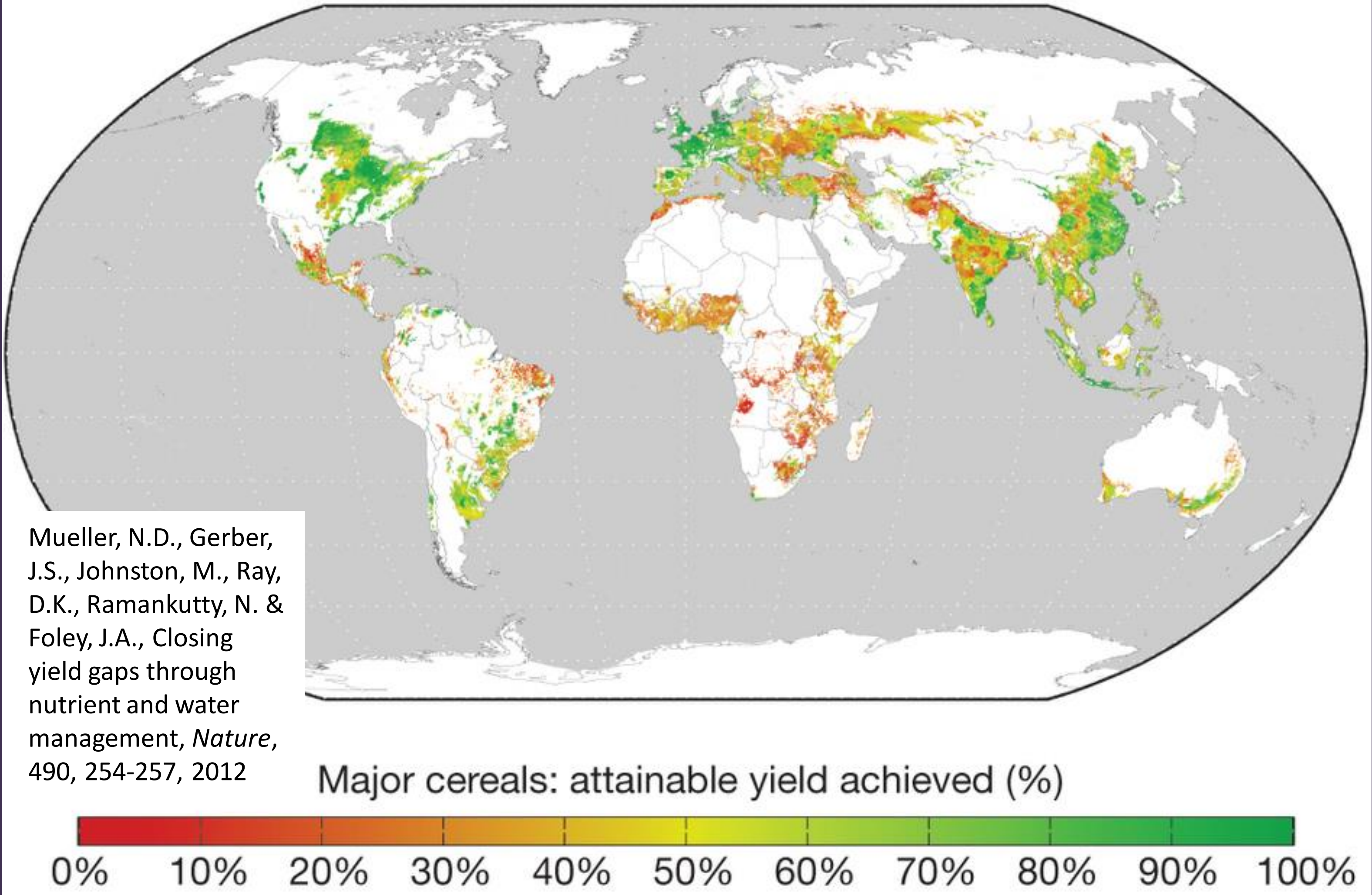
emerging issues

- **need to increase food production because of population increase and fight of malnutrition**
- **need of direct access to food in those countries that export food,**

so increasing the need of food production in the net importing countries

Solutions (1/4)

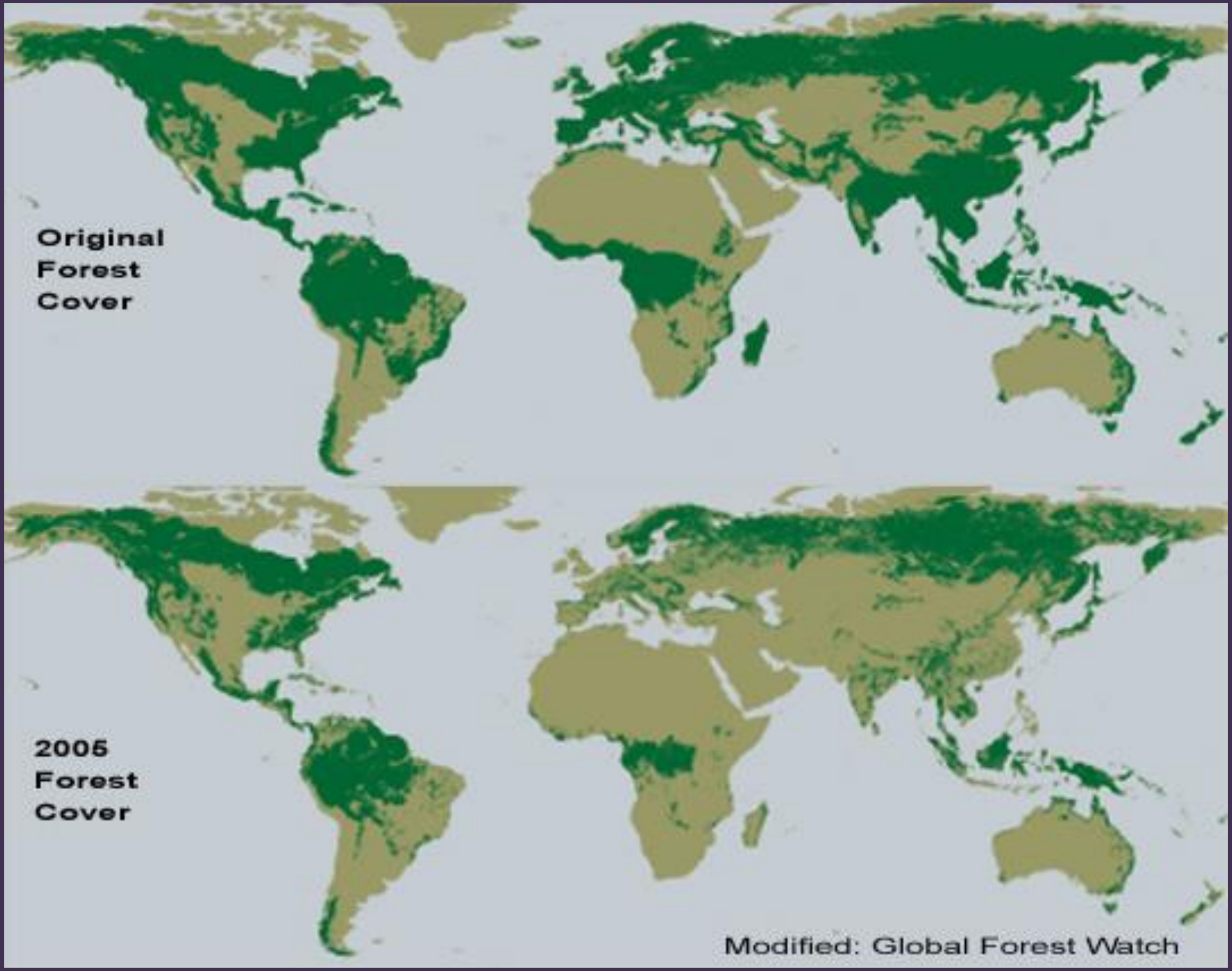
Enhancing efficiency of agriculture: *yield gap closure* wher possible



Mueller, N.D., Gerber, J.S., Johnston, M., Ray, D.K., Ramankutty, N. & Foley, J.A., Closing yield gaps through nutrient and water management, *Nature*, 490, 254-257, 2012

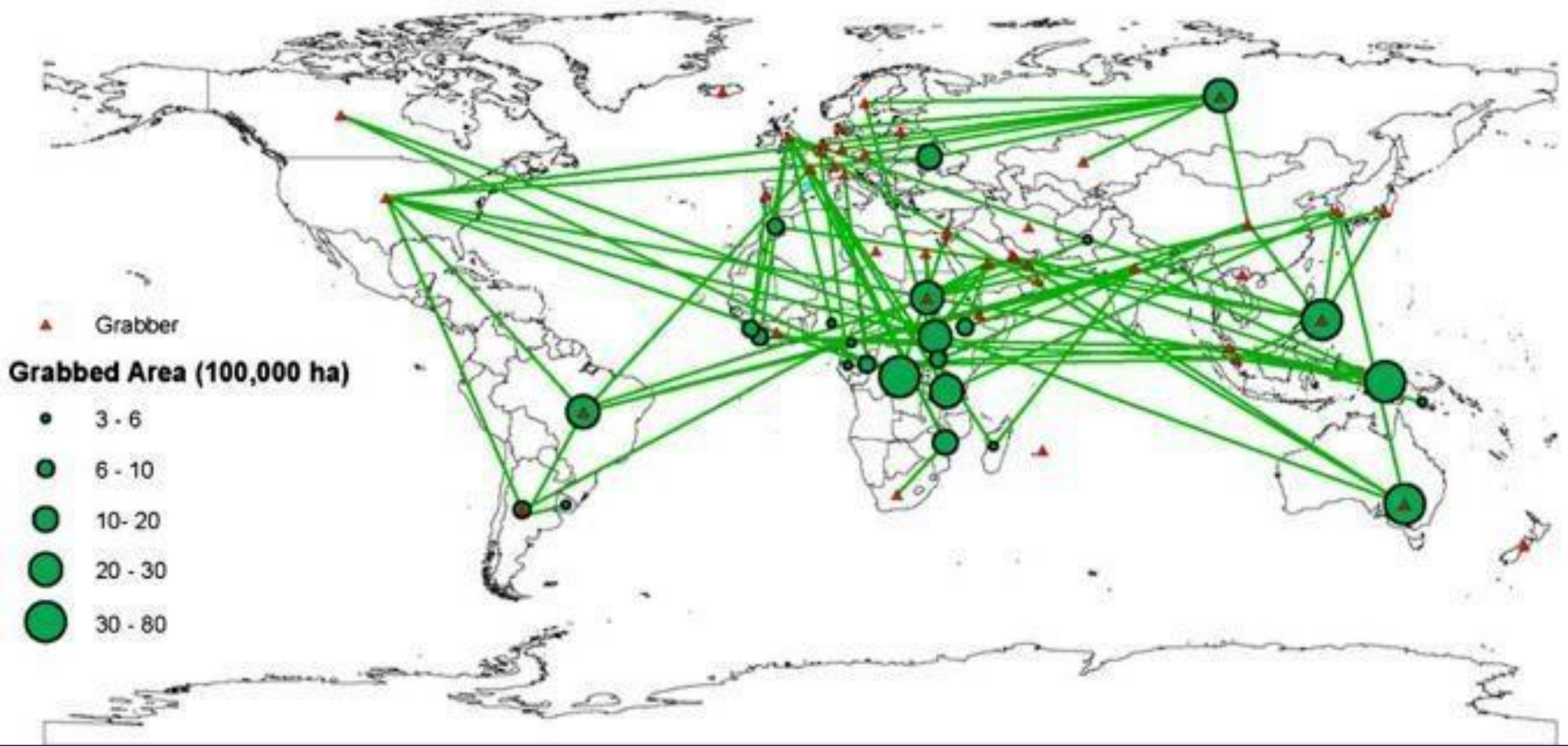
Solutions 2/3

increase agricultural areas
(so decreasing those available for other ecosystems, mainly forest)



Solutions 3/3

Large scale land reclamation for agricultural use



Rulli, M.C., Saviori, A. & P. D'Odorico, Global land and water grabbing, *Proc. Natnl Acad. Sci., USA*, *PNAS,* 110(3), 892-897, 2013.

- *Water is the major factor limiting food production*

- *Some countries currently face persistent and inherent water deficit*

- *In next future, in spite of any policy to avoid food waste that nevertheless can no longer put off, there will be the need of incresing food production*

- *Net import countries must improve local direct access to food*

Virtual water trade does not respond to long term issues

because both import and export countries rely on the same resources to support their growth

- ***Direct access to food →***

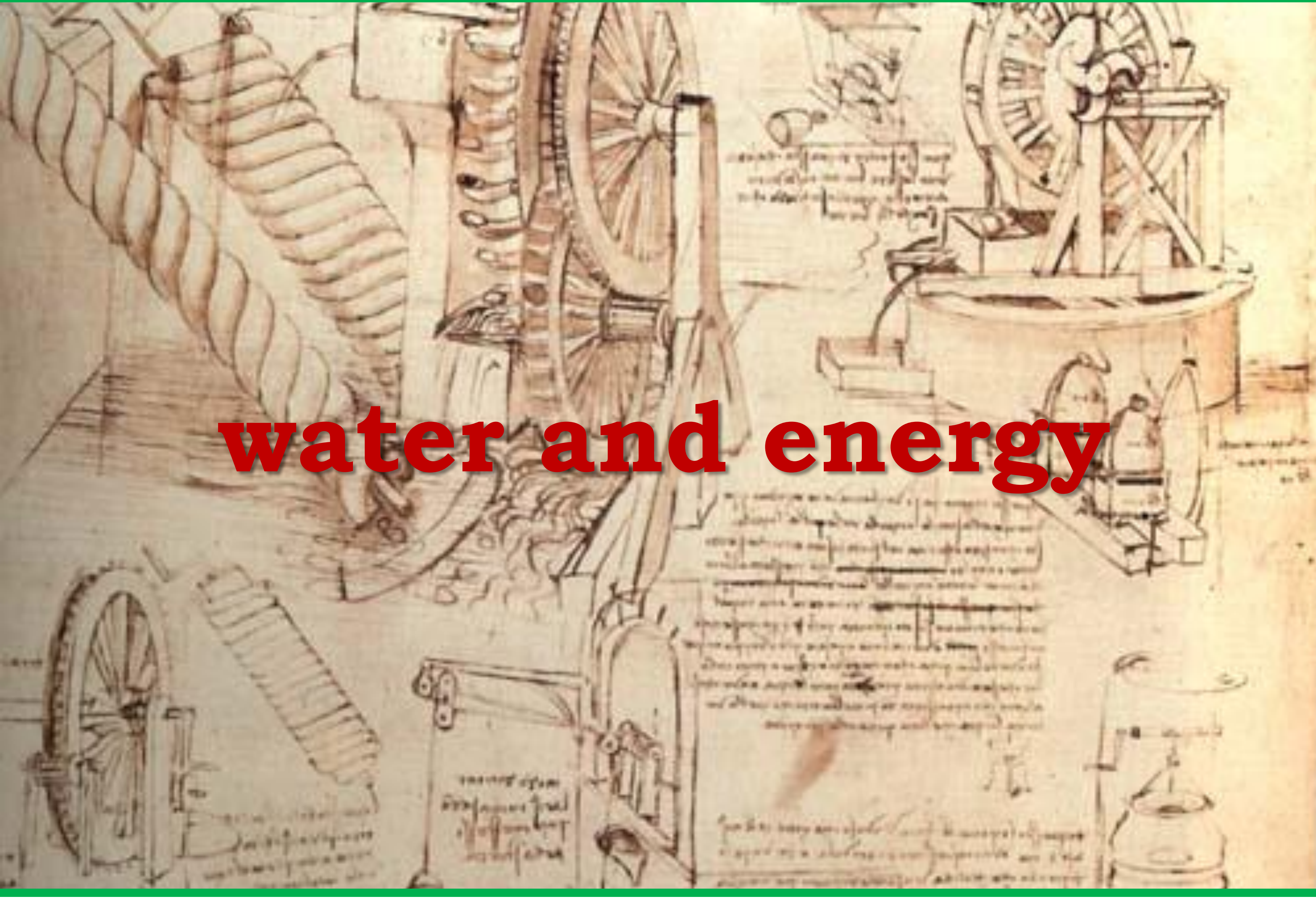
direct resources control →

this yields to large scale land acquisition

(land grabbing)

Closing agriculturla efficiency gap →
trasferring technologies

neeed to introduce rules in order to preserve the rights of local population associated with qeqaulity in the exploitment of availbale water resources



water and energy

growing energy implies growing water consumption

The EIA's International Energy Outlook 2013 predicts 2.2% annual growth in electricity delivered to end-users through 2040

With this staggering growth projection, the ability to produce affordable, sustainable energy becomes more essential than ever to secure economic stability and growth

And since most major sources of energy require large amounts of water, this means that existing water sources will be put under even more strain beyond the effects of increasing population and growing agricultural demands

growing energy implies growing water consumption, 2

Reports indicate that an estimated **78% to 90%** of **power plants** across the world heat water into steam to turn large turbines attached to a generator

Additionally, water serves as the **primary coolant** in power generating stations, maintaining appropriate temperatures for verything from coal boilers to nuclear reactors

And water is the **engine of hydro-electrical production**

growing energy implies growing water consumption, 3

It is not only on-site electricity generation that relies on water **drilling, extraction and processing of fuels** also require significant amounts of water

Methods such as **mining** or **hydraulic fracturing**, which releases trapped oil and natural gas deep underground, are water-intensive practices, accounting for the use of billions of gallons of water worldwide every year

38% of **shale gas** fields worldwide is located in areas where water supply faces water stress or scarcity and, among these souces, 40% of major resources is facing severe freshwater supply constrains

(Financial Times, September 2014)

growing energy implies growing water consumption, 4

All forms of energy require water at some stage of their life cycle: from production to distribution and use.
water is a major component in thermoelectric and hydropower generation today but….

even producing **photovoltaic solar panels** consumes significant amounts of water: the average solar panel manufacturing facility uses more than 1,000 cubic metres of water a day

water scarcity implications for energy generation

Water scarcity has direct implications for energy security

The potential for economic development and stability enabled by a reliable, stable and sustainable supply of energy at affordable prices is limited in a growing number of areas by a lack of access to water

To date, energy and water infrastructure and policy decisions have been made independently of one another, often with outdated assumptions regarding rising demand and resource scarcity

water scarcity implications for energy generation, 2

Any energy policy being drafted in these regions will have to consider that power plants across these areas will face some form of water scarcity

The life cycle of power plants is estimated at on average 20-40 years, so any electric generation facility being planned or under construction in these regions will have to factor water scarcity into the equation.

lack of planning

Today, the use of additional energy extracts more water and speeds the depletion rate of groundwater and rivers.
The hydrological systems of local ecosystems struggle to compensate and adapt
Aquifer replenishment can take hundreds or even thousands of years, so once the extraction of water in aquifers outpaces the rate of infiltration, water scarcity exerts pressure on the operations of end users

In regions affected by water scarcity, electricity generation competes for water against other uses, like drinking water and agricultural irrigation. When this occurs, case studies show that water use for human consumption and agriculture is given priority over energy generation. This means that, in some extreme cases, power plants have to lower their output and incur high financial losses.

lack of planning, 2

Year 2006 drought in Europe (and Italy, mainly in the Po river valley) resulted in energy losts from both

- **hyro-elecrtical** plants (also to sustain downstream river drougth)
- **thermo-electrical** plants (lack of cooling water supply)
- **nuclear** plants in France and Germany (this enhancing failure risk)

In 2011, Texas experienced the **worst single-year drought** in its history

The drought ruined **cotton crops** and forced ranchers **to sell cattle that would have otherwise died**

This drought also affected **regional energy sources**, raising concern among grid operators

It became apparent that **there would not be enough water** for all the usual demands

lack of planning, 3

Brazil drought 2013-2014

(Brazil is the second largest hydro-energy producer in the world)

- reduced hydropower production
- dramatic energy price increase
- this has pushed towards wind energy exploitation

California current drought

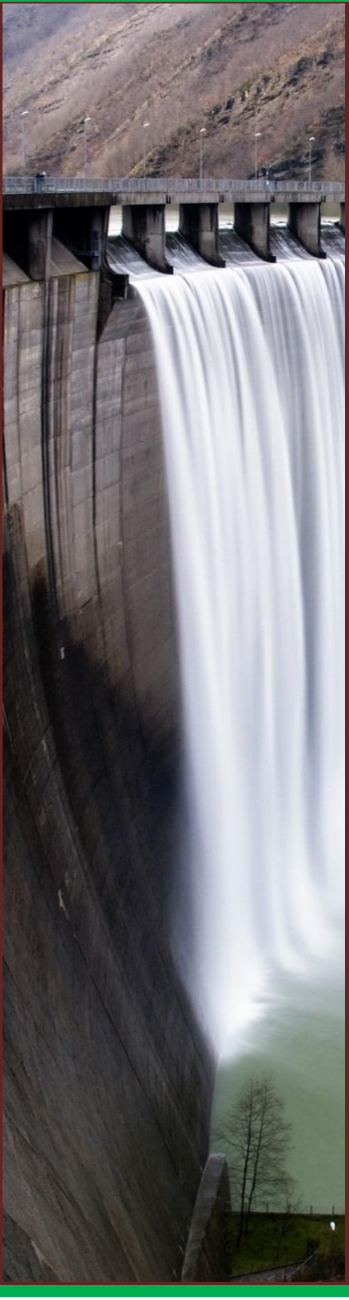
Hydropower dams in California have the capacity to generate **14,000 MW**

On average, **25,000 gigawatt-hours** (GWh) are generated

In a **dry year**, about **15,000 GWh** of energy are produced (roughly the same as solar)

and in a **wet year**, about **40,000 GWh** can be generated

ALMONDS vs POWER….?



lack of planning, 4

India is another prime example of the trade-offs that come with water scarcity.
Farmers have desperately attempted to draw crops from the land despite a lack of water, often using enormous amounts of energy to pump water from deep underground.
Some estimates suggest that energy usage in certain drought-stricken areas has increased by 25%.
This energy used to collect water comes from electricity generating stations that must use even more water to satisfy, so producing a **dramatic positive feeback effect**

Meanwhile, India has approved a plan to build new hyrdropower with a total of
50 TeraWatt *g.i.p.* in forthcoming 10 years

solutions?

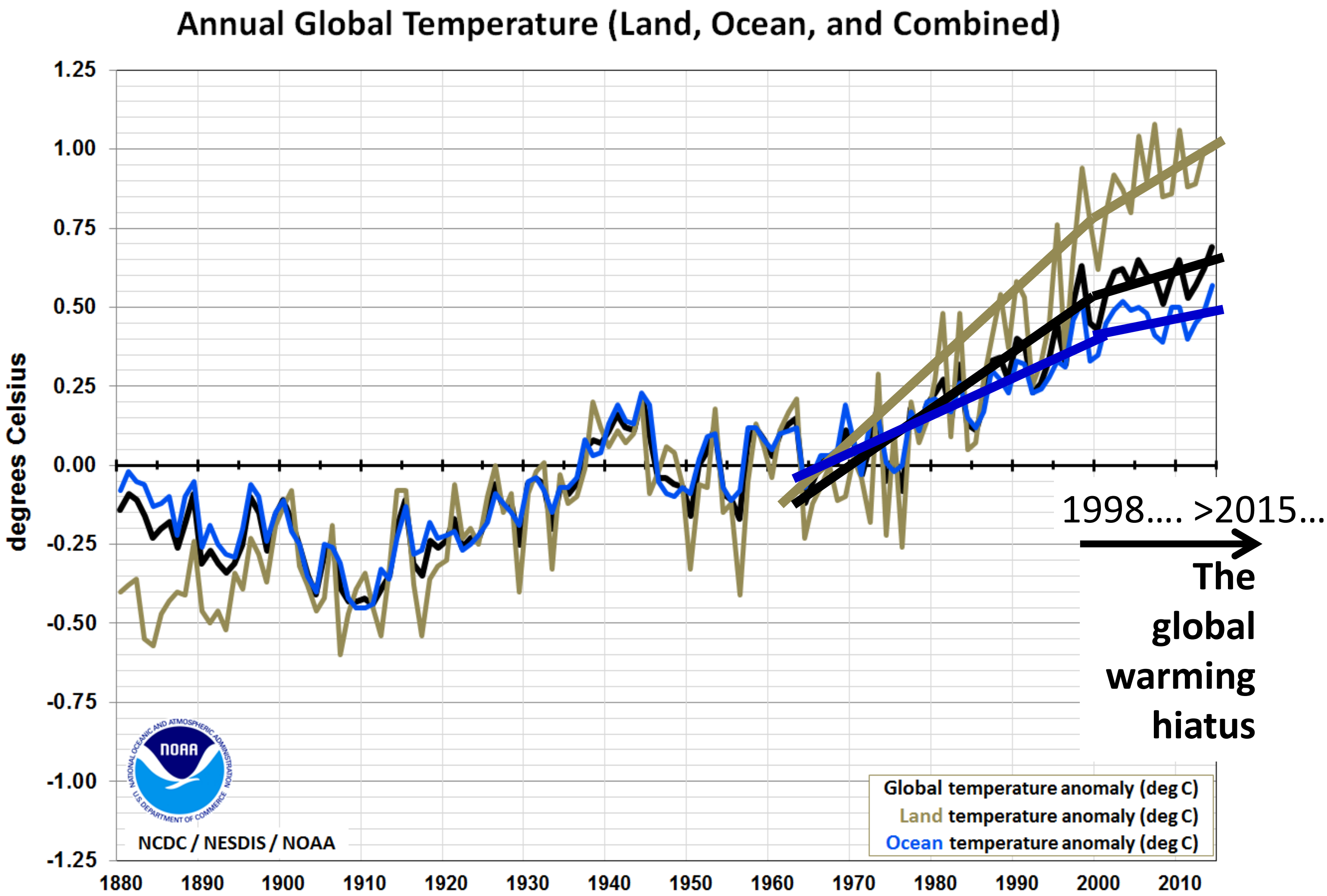
de-couple the growth of energy demand from water demand

revise current water and energy policies and infrastructure

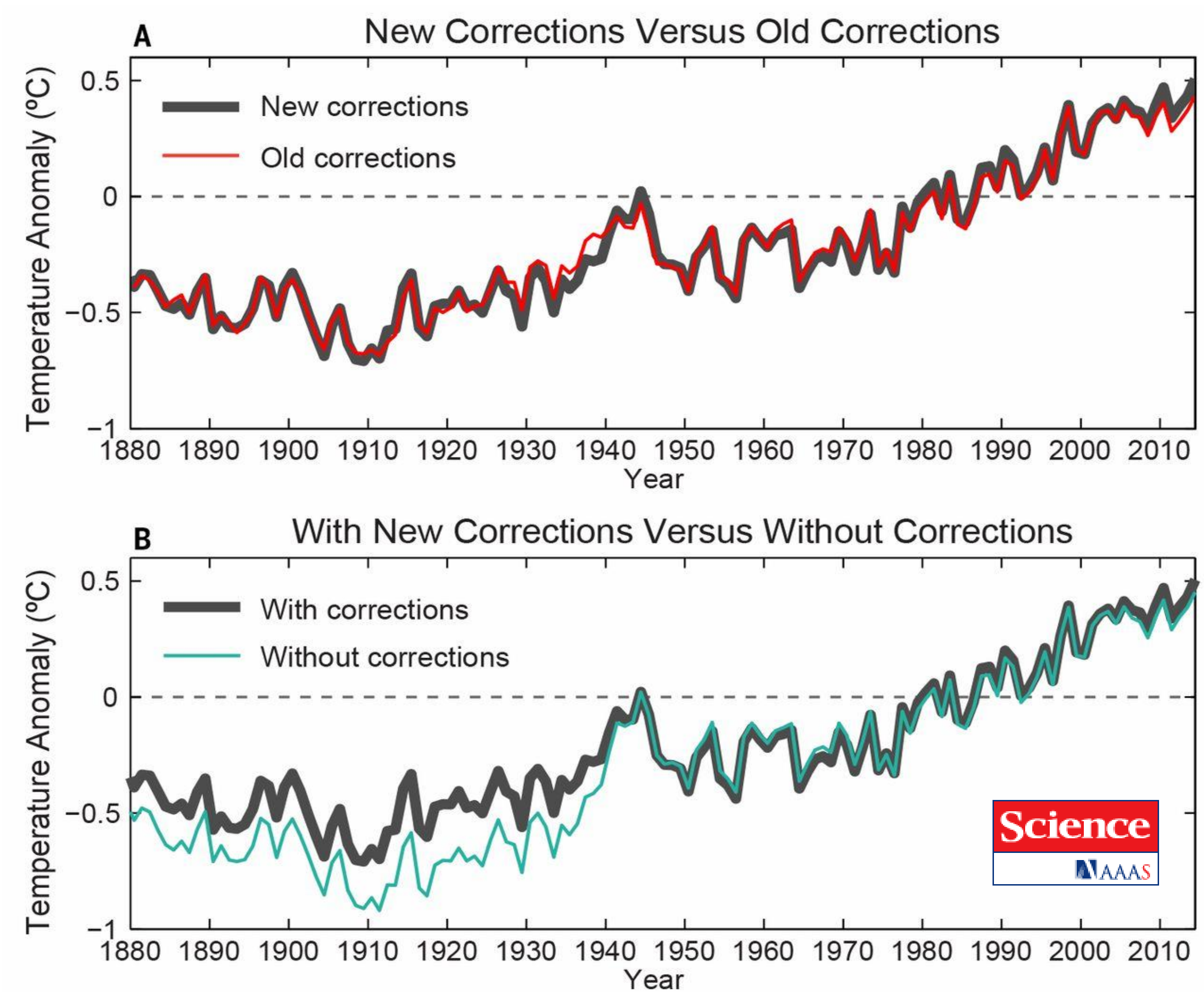
emphasize the economic value of water

focusing on innovation

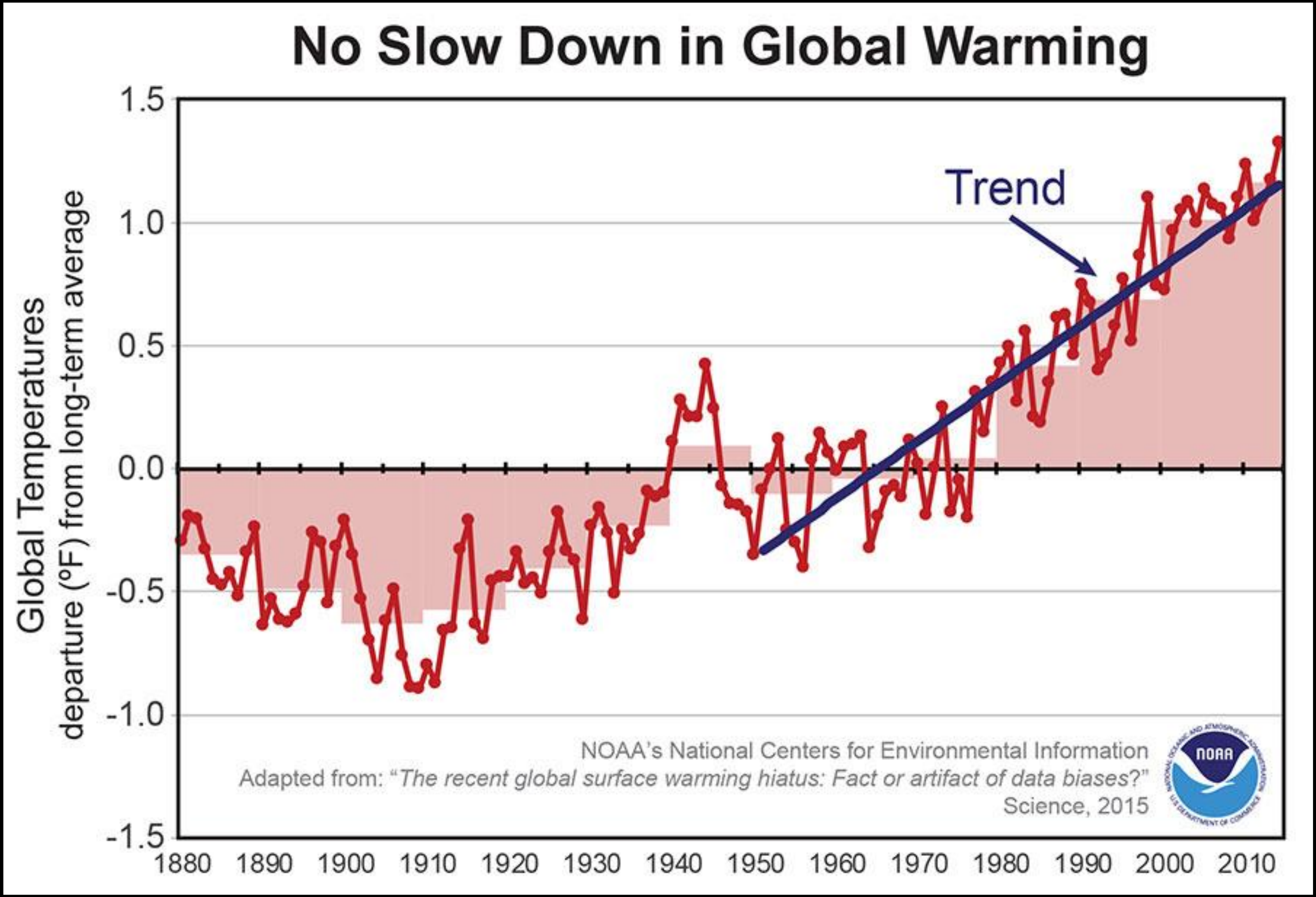
water and climate



Temperature Time-Series for land-only, ocean-only, and combined land-and-ocean (source: NOOA, 2014)



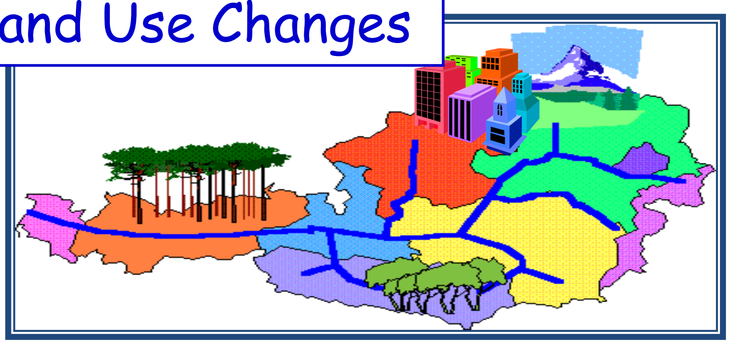
Global (land and ocean) surface temperature anomaly time series with new analysis, old analysis, and with and without time-dependent bias corrections (source: Karl, T.R. et al. Science 2015;science.aaa5632)


No Slow Down in Global Warming
Global Temperatures
departure (ºF) from long-term average
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Trend
NOAA's National Centers for Environmental Information
Adapted from: "The recent global surface warming hiatus: Fact or artifact of data biases?"
Science, 2015
NOAA

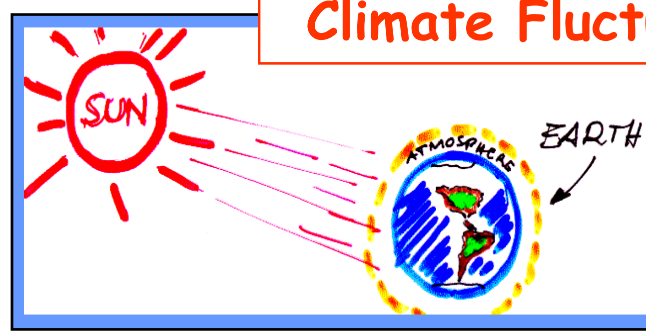
Non-stationarity in the Hydrological Cycle

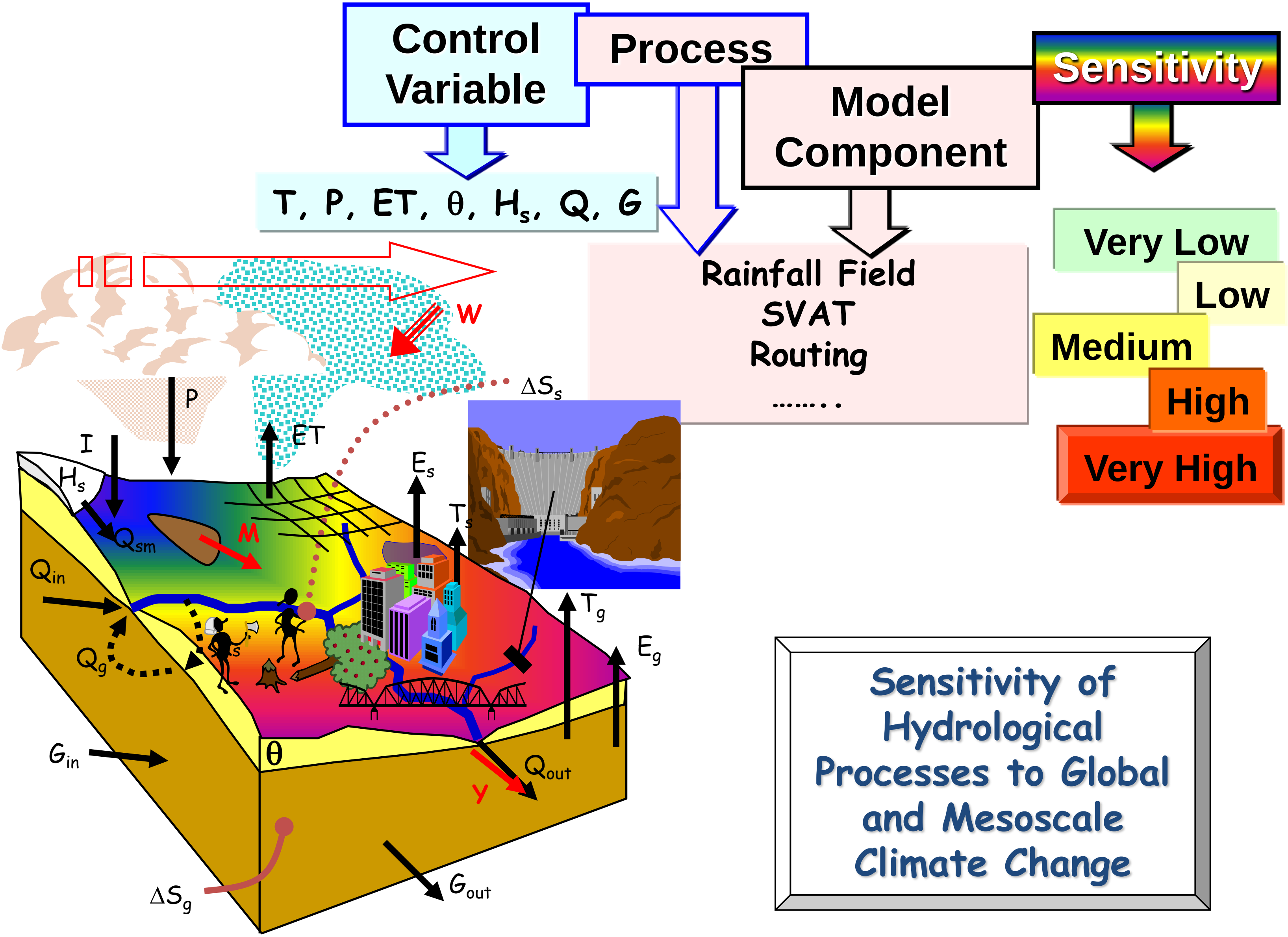
- Transients and Low Frequency Periodicity
  - Factors of NonStationarity
    - Land Use Changes
    - Climate Fluctuations
- High Frequency Periodicity
  - Daily Cycle
  - Seasonality
- Short Term Evolution

Land Use Changes



Climate Fluctuations



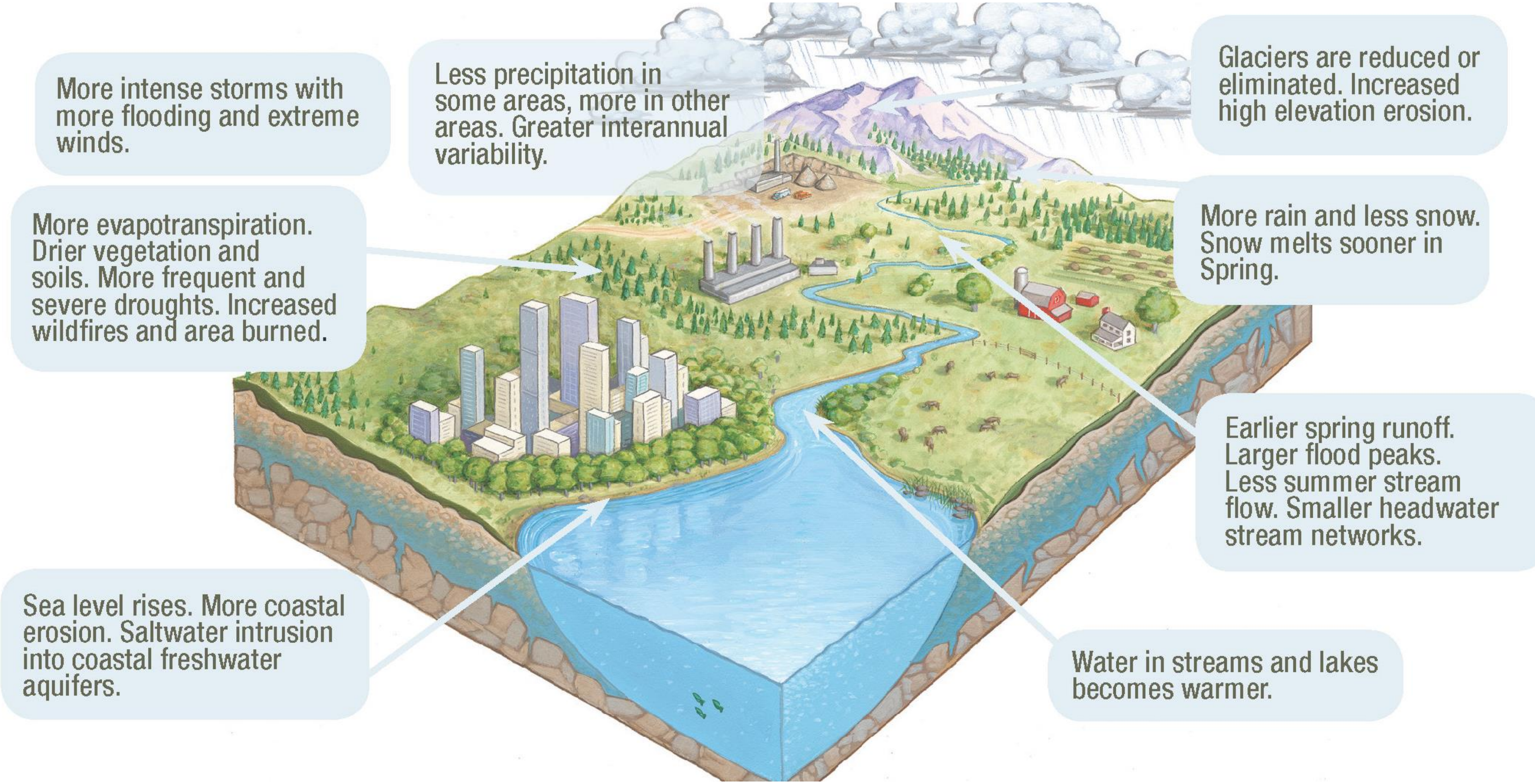


Sensitivity of Hydrological Processes to Global and Mesoscale Climate Change

Sensitivity of Flood Hydrology Processes to Global and Mesoscale Climate Change

Control Variable	Process	Flood Model Component	Sensitivity
Temperature Soil Moisture	Evapotraspiration and Soil Water Dynamics	Initial Soil Moisture Condition and Groundwater Level	Medium
Rainfall	Storm Field Dynamics	Storm Rate and Spatial Distribution	Very High
Temperature Rainfall Snow Cover	Snow Cover and Glacier Dynamics	Snowmelt	Very High
Temperature Precipitation Soil Moisture	Infiltration and Surface Runoff	Hillslope Response	High
Streamflow	Flow Dispersion and Propagation	River Network Response	Low

predicted climatic changes to the hydrological cycle



METHODS for ANALYSING the INTERACTION between Climate Hydrology

Paleo Climate Analogues

- geologic shifts may differ from anthropogenetic change
- farther going back, the more difficult to recover data
- past change predate human activity:
- no evidence of impact on society

HELP UNDERSTANDING THE EVOLUTION OF CLIMATE

Recent Climate Analogues

- short records yield strong uncertainties
- causal effects (natural or anthropogenic) may differ

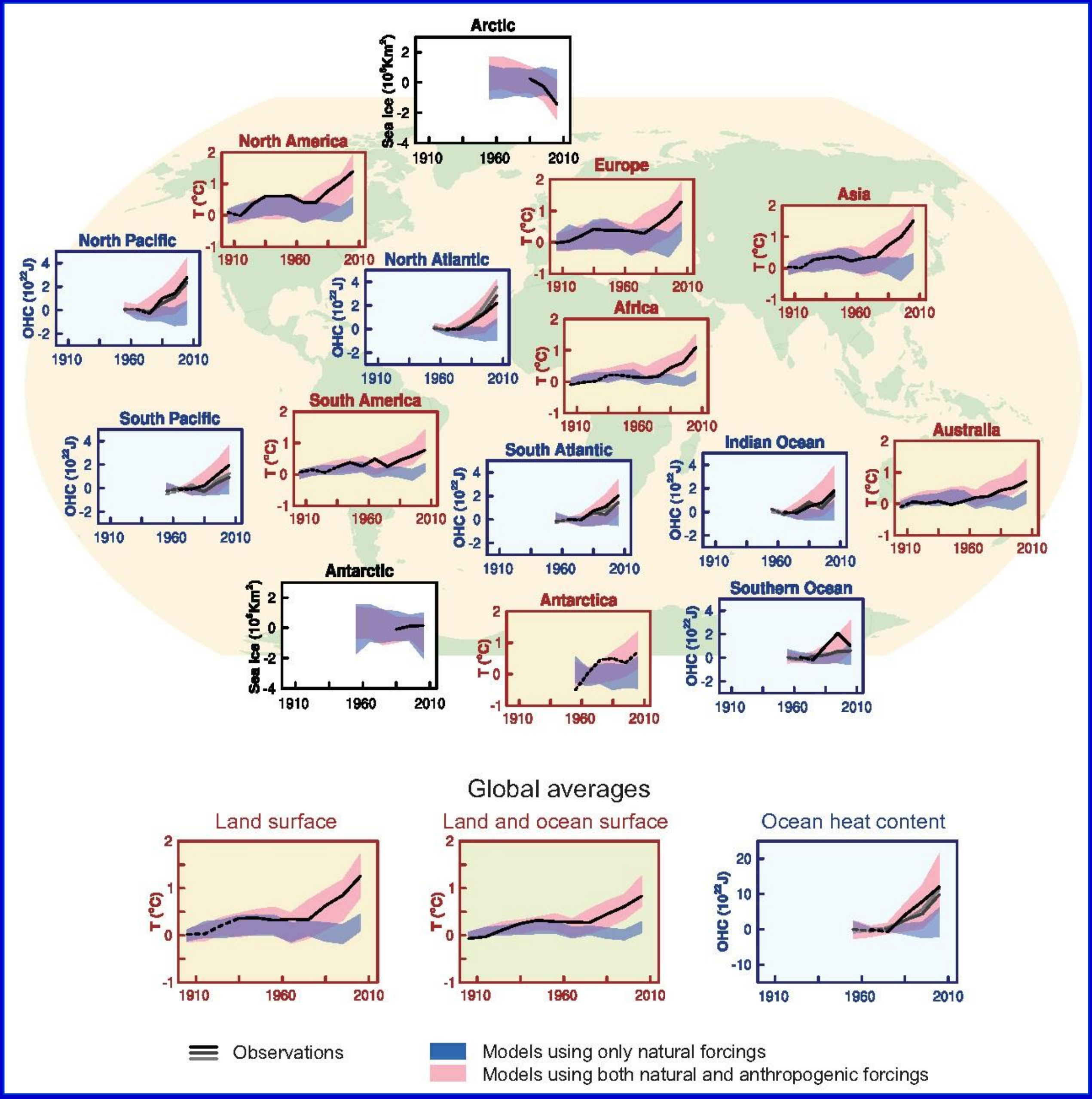
GIVE AN INSIGTH OF VULNERABILITY OF PRESENT SOCIETY TO FUTURE CLIMATE CHANGES

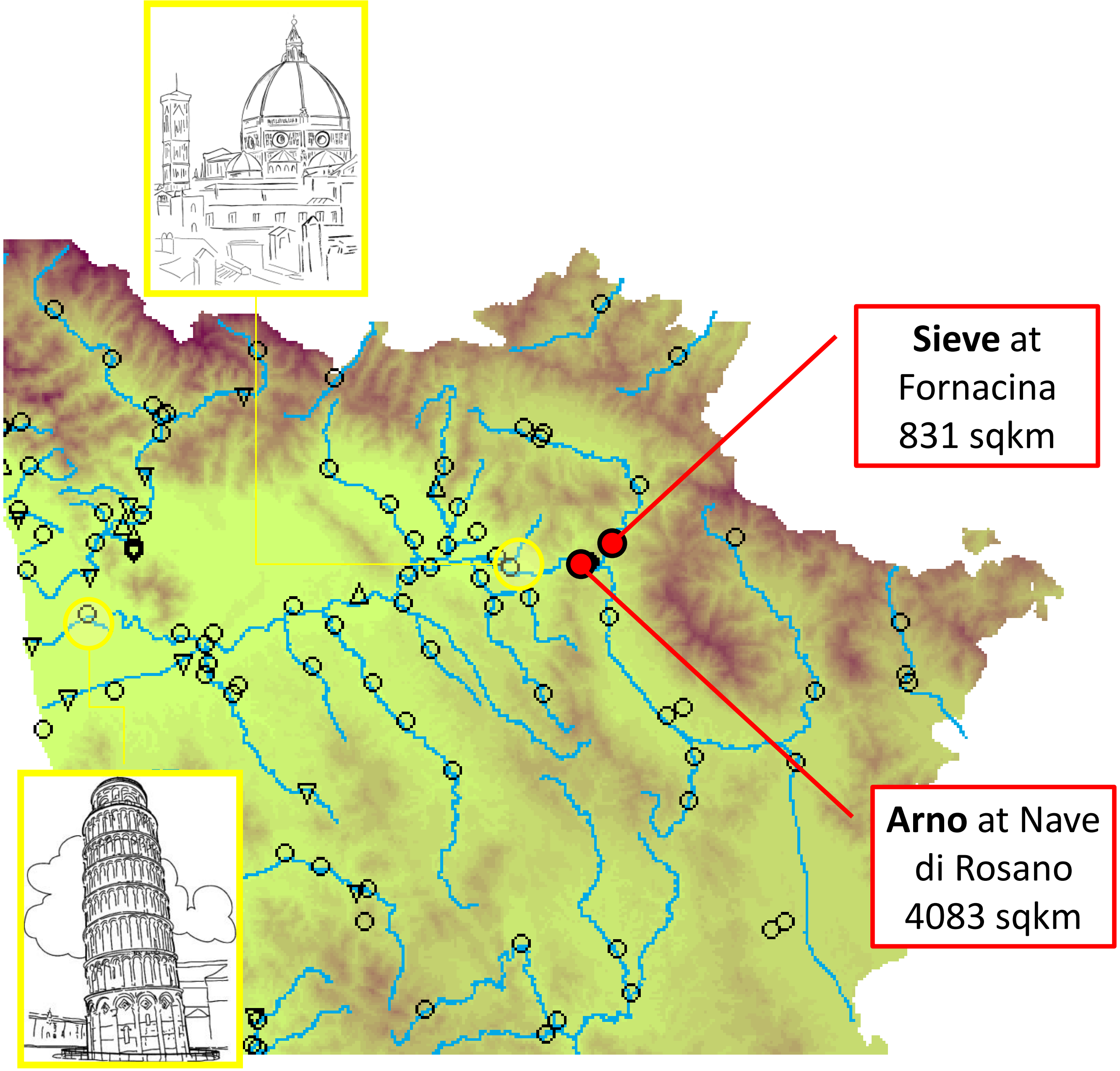
HELP DETECTING THE STRUCTURAL PROPERTIES OF CLIMATOLOGIC VARIABLES AND PROCESSES

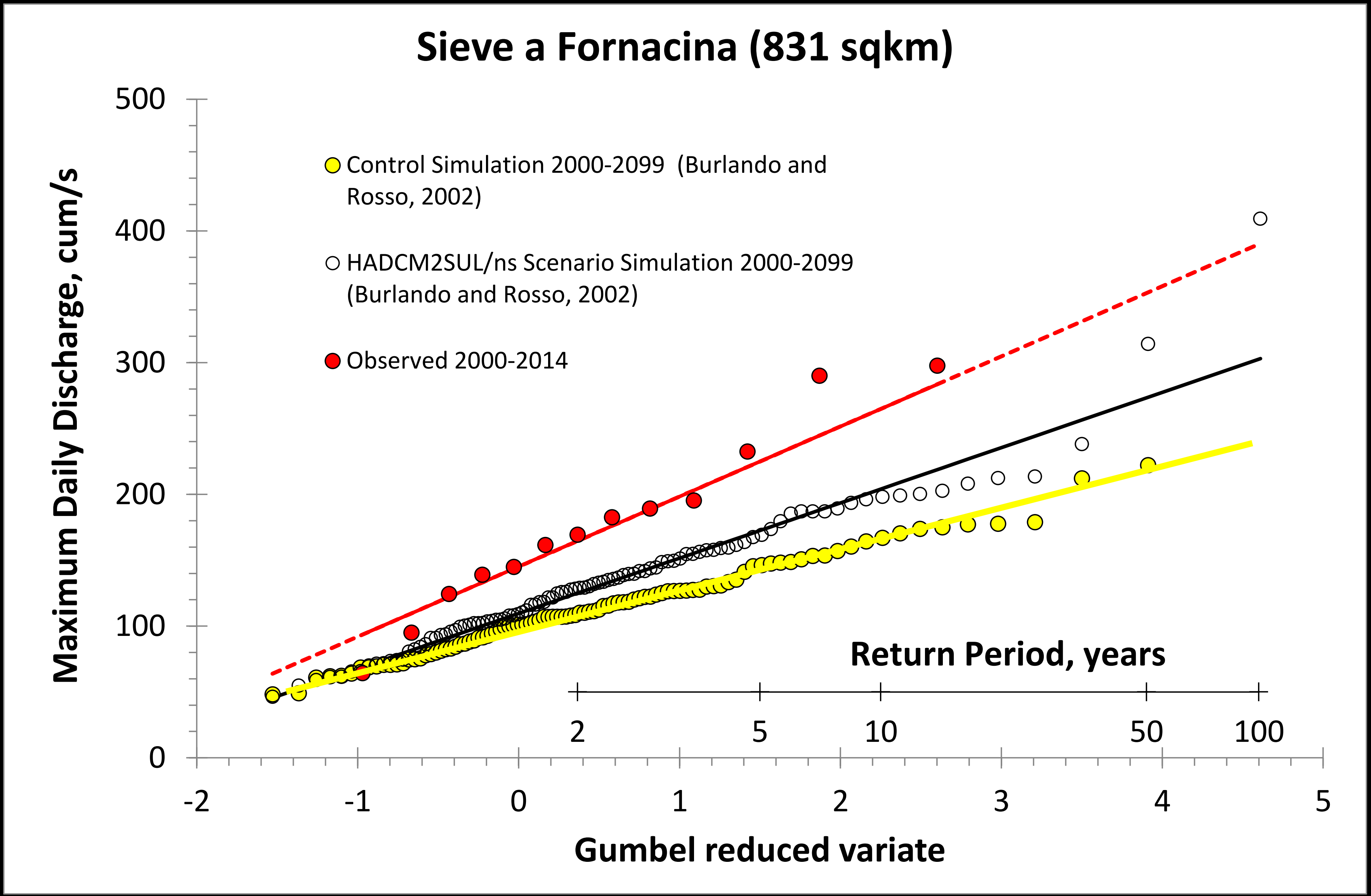
Mathematical Models

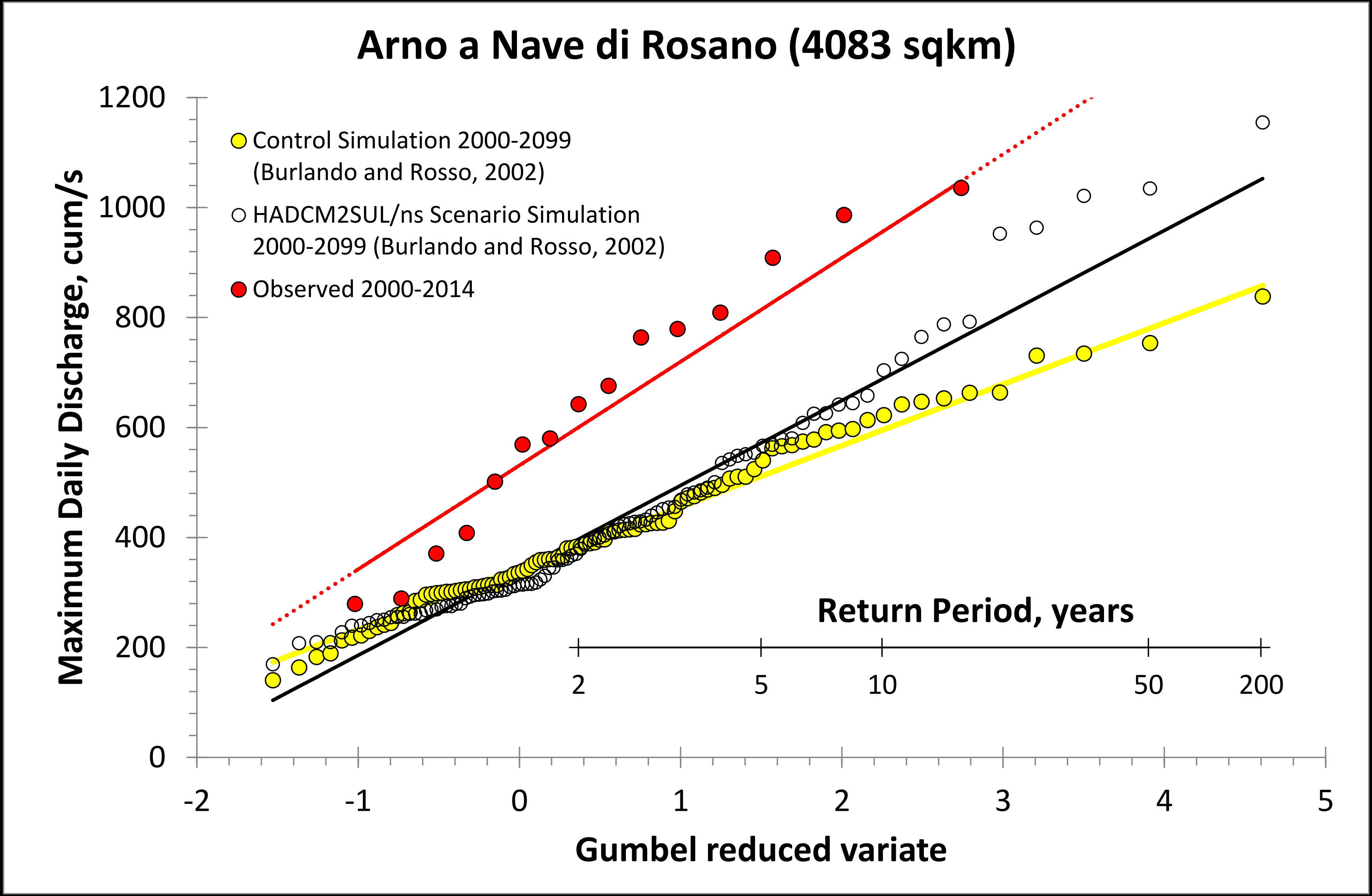
- large unceirtainties in climatologic dynamics
- poor control observations from the monitoring network

A LABORATORY TO INVESTIGATE GLOBAL CLIMATE
DETAILED DESCRIPTION FROM 1D TO 3D EFFECTS
ALLOW FOR "CONTROL" AND "PERTURBED" SIMULATIONS


Arctic
Sea ice (10⁶Km²)
North America
Europe
Asia
North Pacific
North Atlantic
Africa
South America
South Pacific
South Atlantic
Indian Ocean
Australia
Antarctic
Antarctica
Southern Ocean
T (°C)
OHC (10²²J)
1910
1960
2010
Global averages
Land surface
Land and ocean surface
Ocean heat content
Observations
Models using only natural forcings
Models using both natural and anthropogenic forcings


Sieve at
Fornacina
831 sqkm
Arno at Nave
di Rosano
4083 sqkm

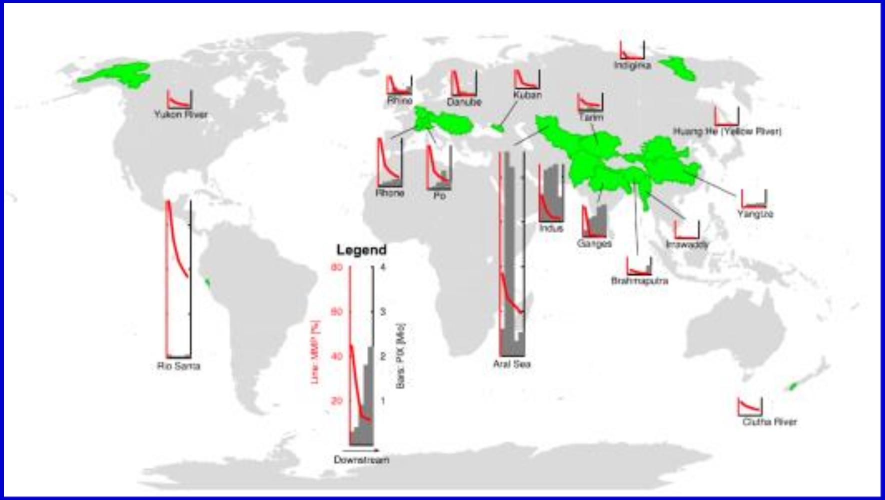

Sieve a Fornacina (831 sqkm)
Maximum Daily Discharge, cum/s
Control Simulation 2000-2099 (Burlando and Rosso, 2002)
HADCM2SUL/ns Scenario Simulation 2000-2099 (Burlando and Rosso, 2002)
Observed 2000-2014
Return Period, years
2
5
10
50
100
500
400
300
200
100
0
-2
-1
0
1
2
3
4
5
Gumbel reduced variate


Arno a Nave di Rosano (4083 sqkm)
Control Simulation 2000-2099 (Burlando and Rosso, 2002)
HADCM2SUL/ns Scenario Simulation 2000-2099 (Burlando and Rosso, 2002)
Observed 2000-2014
Maximum Daily Discharge, cum/s
0
200
400
600
800
1000
1200
Return Period, years
2
5
10
50
200
-2
-1
0
1
2
3
4
5
Gumbel reduced variate


water towers
and
climate

Impacts of Climate Change on Ecosystem Services

Basin name	Basin area, km²	Glacier area, km²	Glacier area, %	Population, 10^6	PIX, 10^6
Aral Sea	1,234,075	11,319	0.92	41.01	10.29
Indus	1,139,814	20,325	1.78	211.28	4.82
Ganges	1,023,609	12,659	1.24	448.98	2.40
Po	73,297	818	1.12	16.55	0.81
Rhone	97,702	1,162	1.19	10.12	0.57
Rhine	190,713	459	0.24	59.07	0.52
Yangtze	1,746,593	1,895	0.11	383.04	0.37
Brahmaputra	527,666	16,118	3.05	62.43	0.31
Danube	794,133	617	0.08	81.38	0.31
Tarim	1,053,180	20,494	1.95	9.22	0.30
Rio Santa	11,901	503	4.23	0.57	0.27
Kuban	59,120	215	0.36	3.45	0.05
Huang He	988,702	172	0.02	162.70	0.02
Indigirka	341,577	338	0.10	0.04	0.00
Irrawaddy	410,376	25	0.01	35.26	0.00
Yukon River	830,257	9,070	1.09	0.13	0.00
Clutha River	17,182	147	0.86	0.03	0.00



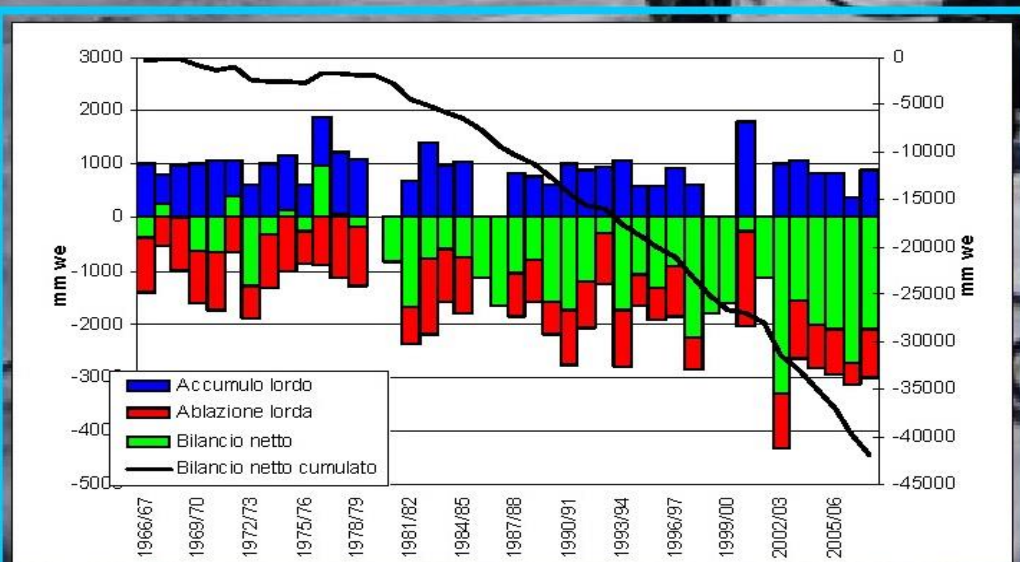

CARESER GLACIER, 1967 (Foto G. Zanon)

retrieved from: C. Casarotto, *Lo stato dei ghiacciai del Trentino*, 2010

Perdita cumulata 1967-2009: - 43,4 m w.e (pari a circa 47,7 m di ghiaccio)

Bilancio netto stagione 2008-09: -1500 mm w.e. (1,6 m ghiaccio)

retrieved from:
C. Casarotto, *Lo stato dei ghiacciai del Trentino*, 2010



water resources from Asian water towers (3a)

the RONGBOK GLACIER (Everest, HIMALAYA)
LOST 106m (in depth) from 1921 to 2008

Shrinking glaciers may initially provide more melt water, but later their amount may reduced.

On the other hand, growing glaciers store precipitation, reduce summer runoff, and can also trigger local hazards.

5

water resources from Asian water towers (3b)

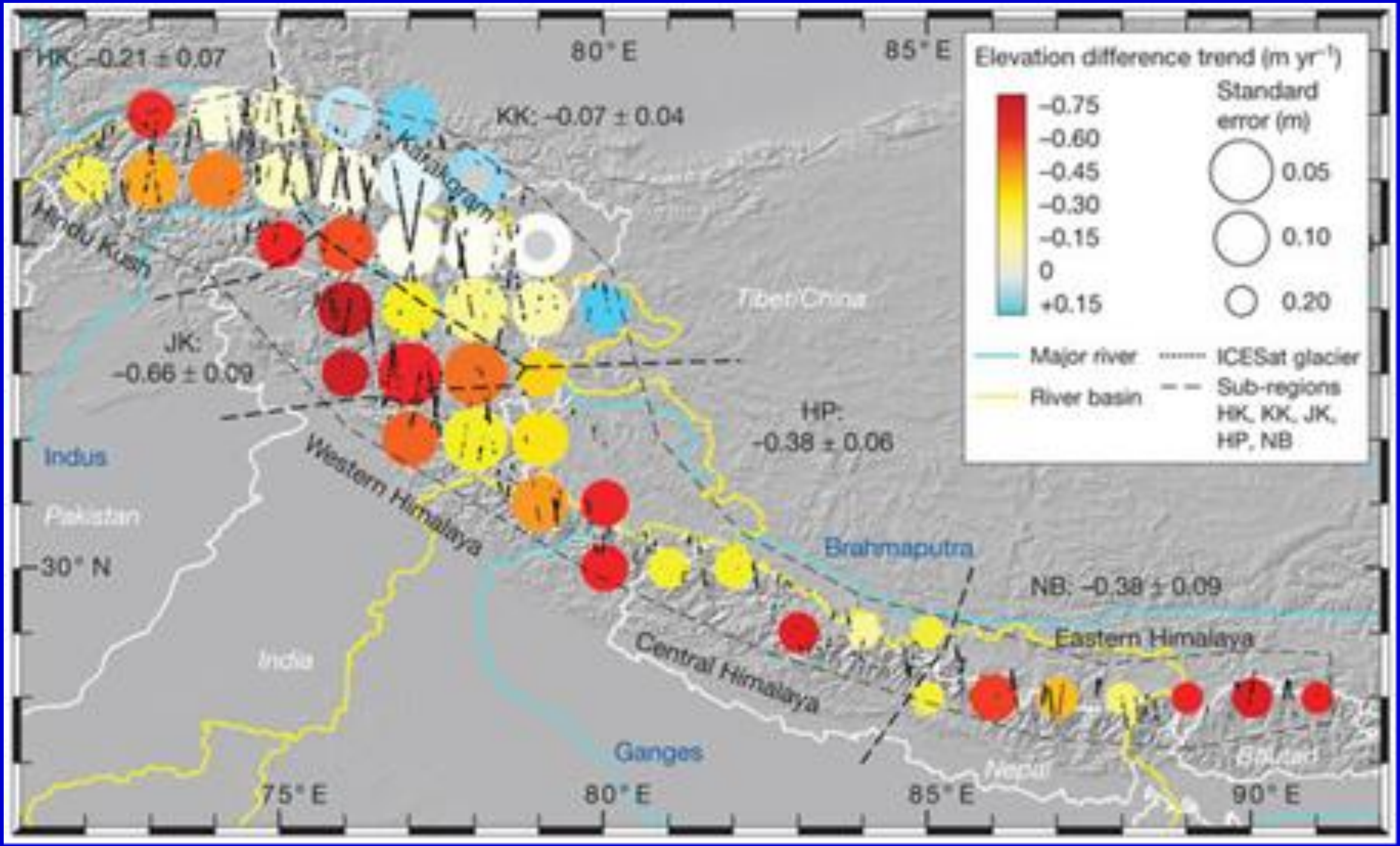
the front of BALTORO GLACIER (KARAKORAM) from 1954/1958 to 2013

Shrinking glaciers may initially provide more melt water, but later their amount may reduced.

On the other hand, growing glaciers store precipitation, reduce summer runoff, and can also trigger local hazards.

6

the Karakorum anomaly

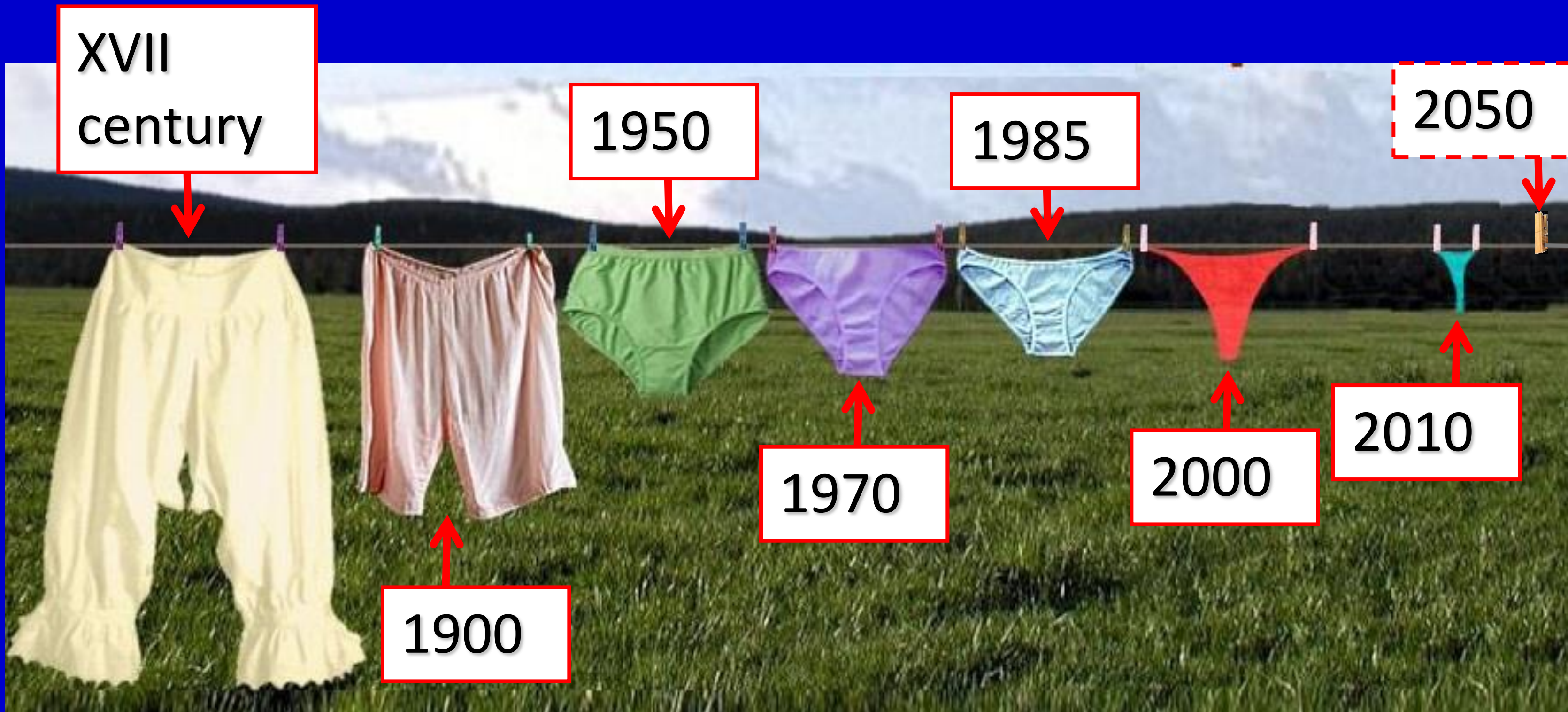


Kaab, A., Berthier, E., Nuth, C., Gardelle, J., & Y. Arnaud, Contrasting patterns of early 21st century glacier mass change in the Himalaya, *Nature*, 488, 495-498, 2012.

Impacts of Climate Change on Ecosystem Services

Baltor Campaign, Field Experiment 2011-2012

SHARE paprika
Stations at High Altitude for Research on the Environment



…such an interchange would not only require a clear delineation of the interface between hydrology and climatology but would probably also call for a clearer understanding of the relationship between theory and practice in each of the two areas

(James D.I. Dooge)

The DOWN-SCALING issue

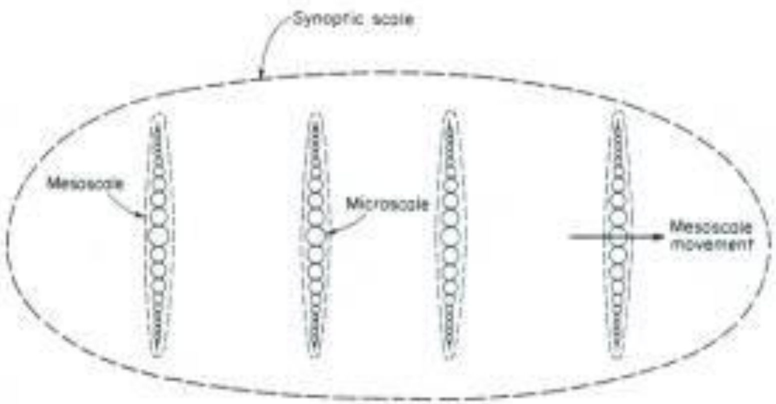
Prediction of future climate scenarios requires use of climate feeding from AOGCMs
(Atmospheric Oceanic Global Circulation Models)

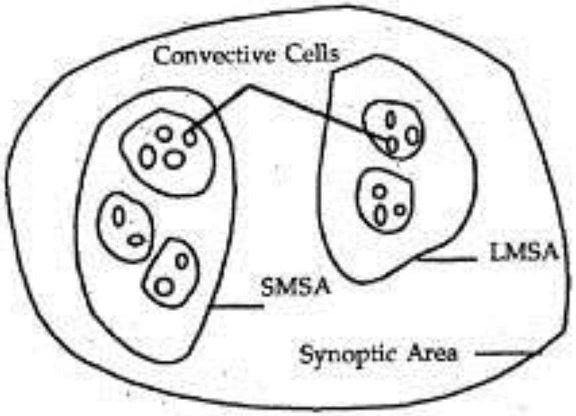
The crucial issue stems form the **bias**, and the **tremendous mismatch** in scales between AOGCMs (100 km), and the hydrological models (1-:-10 km), as required by topographic control

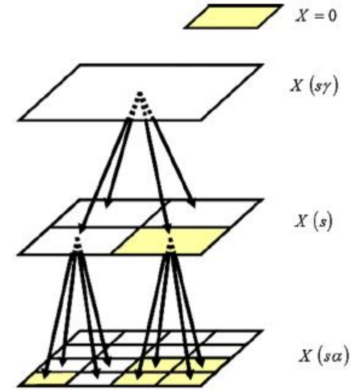
We need some tool to downscale projections of future precipitation from the AOGCM

DOWN-SCALING via RC + SRE

An effective and efficient downscaling approach uses concepts of scale variability of precipitation to obtain statistical downscaling techniques to convey information from GCMs to local scale of hydro-glacio investigation



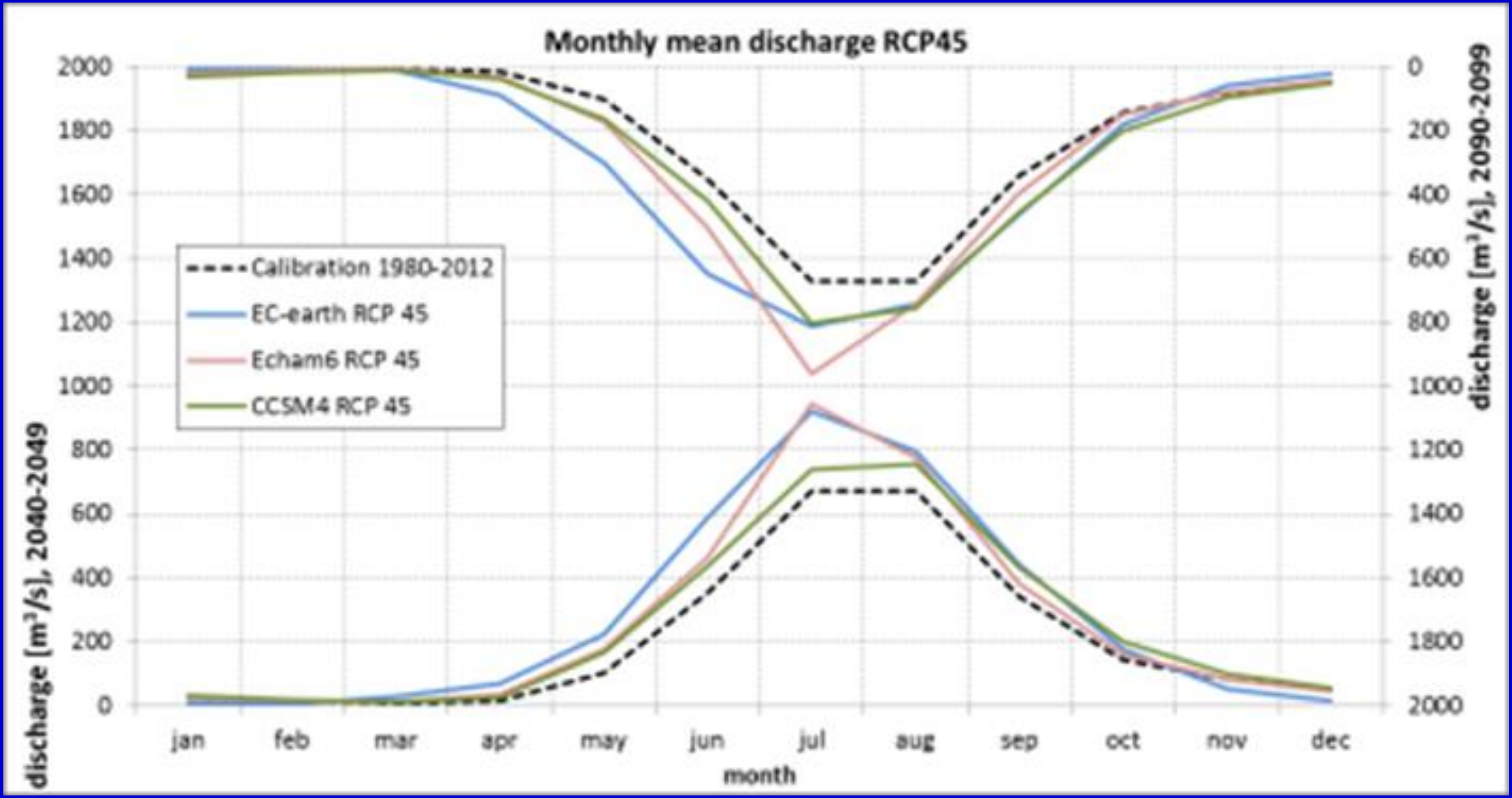




Random Cascade (RC) theory provides an insight of intrinsic, physical structure of precipitation fields

Scale Recursive Estimation (SRE) provides effcient algortihms for model estimation

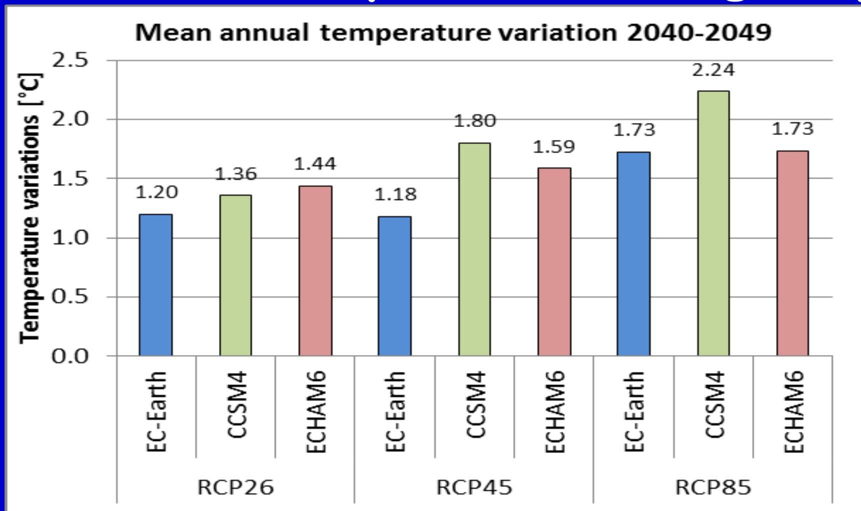
Streamflow will increase during the warm season, as sustained by ice melt, especially during July and August, but with a potential shift of high flows towards Spring months

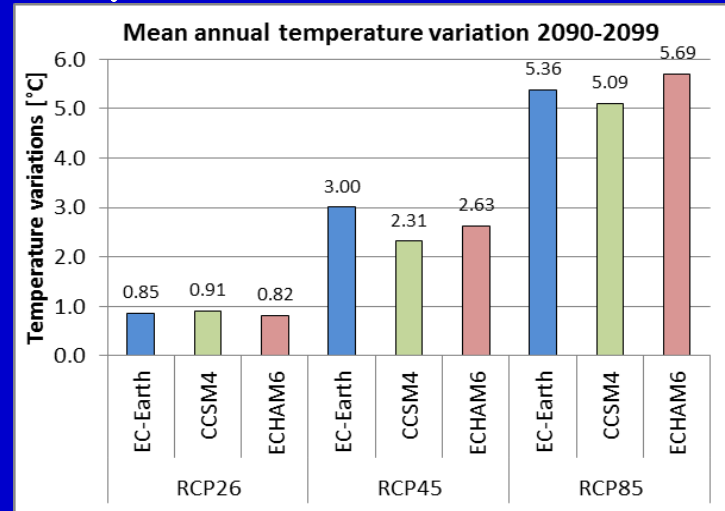


Soncini, A., D. Bocchiola, G. Confortola, A. Bianchi, R. Rosso, C. Mayer, A. Lambrecht, E. Palazzi, C. Smiraglia & G. Diolaiuti, Future Hydrological Regimes in the Upper Indus Basin: A Case Study from a High-Altitude Glacierized Catchment, *J. Hydrometeorology,* in print, 2014.

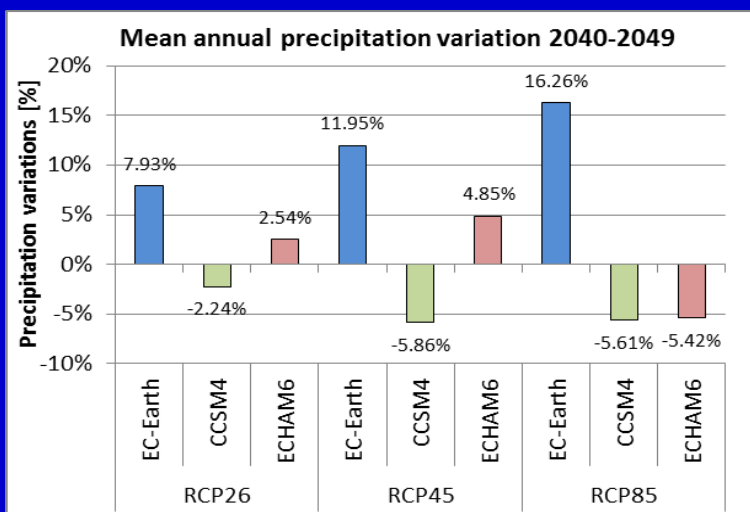
HYDROLOGICAL SCENARIOS, KARAKORUM

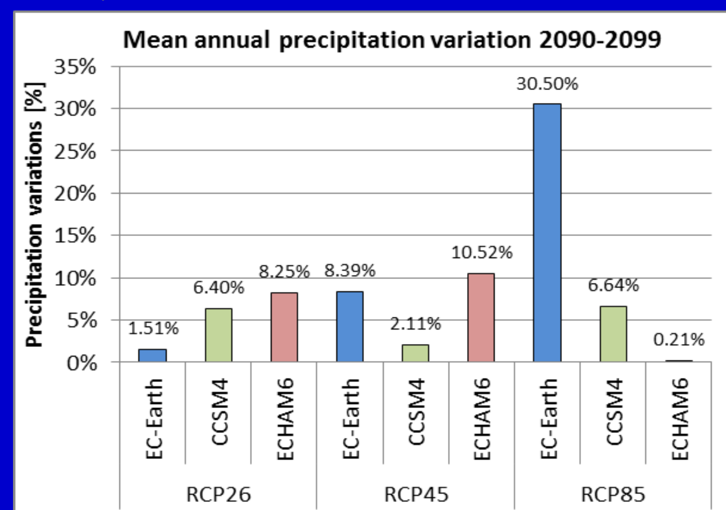
Temperature changes (yearly, Ref. 1980-2012)





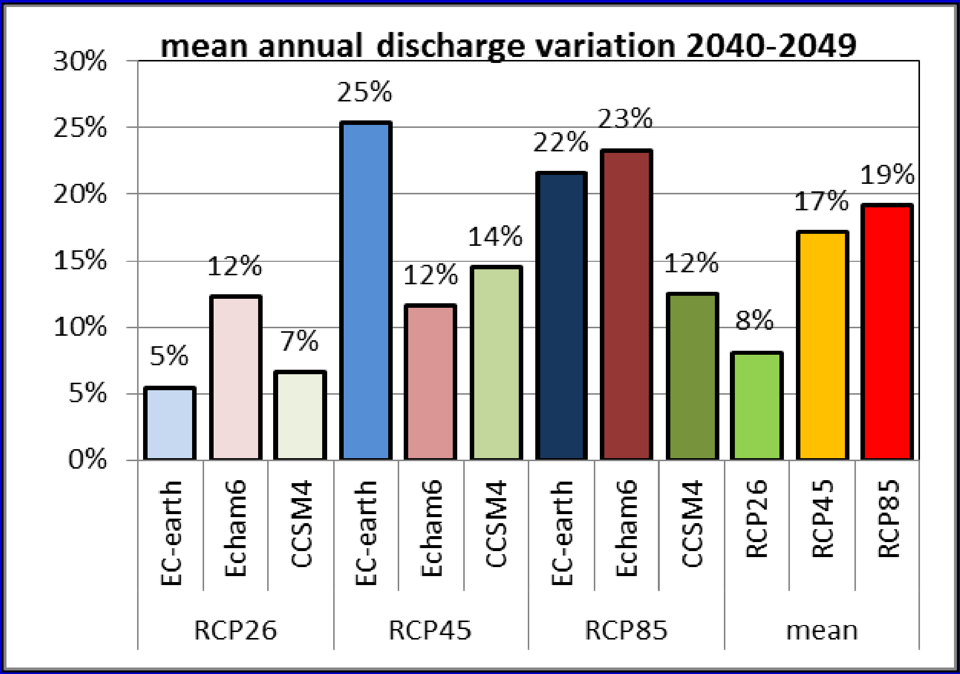
Precipitation changes (yearly, Ref. 1980-2012)

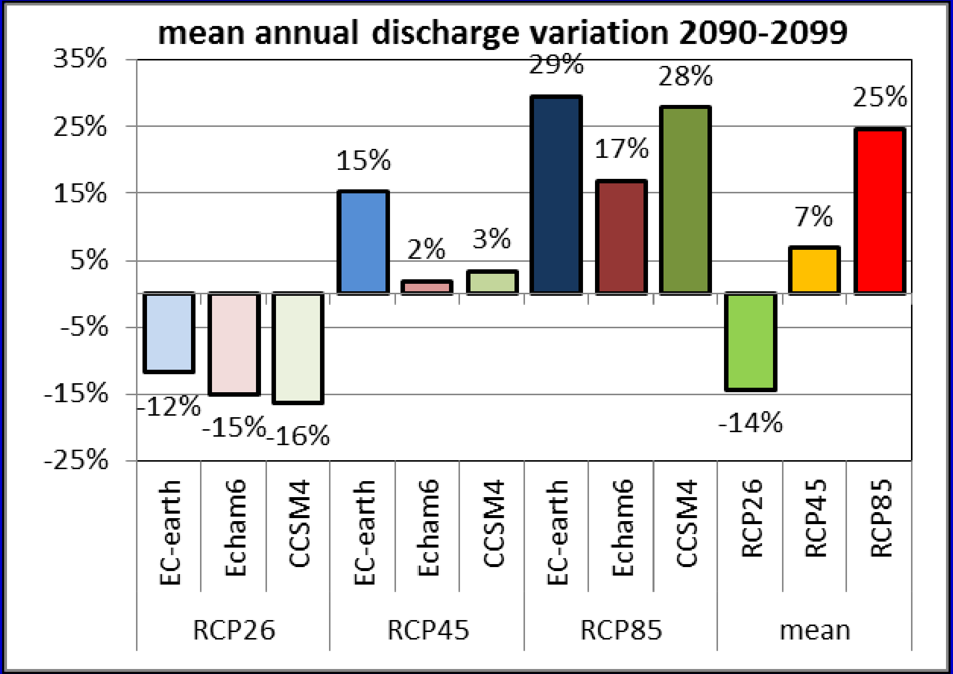




HYDROLOGICAL SCENARIOS, KARAKORUM: INDUS

Mean Annual Streamflow (yearly, Ref. 1980-2012)

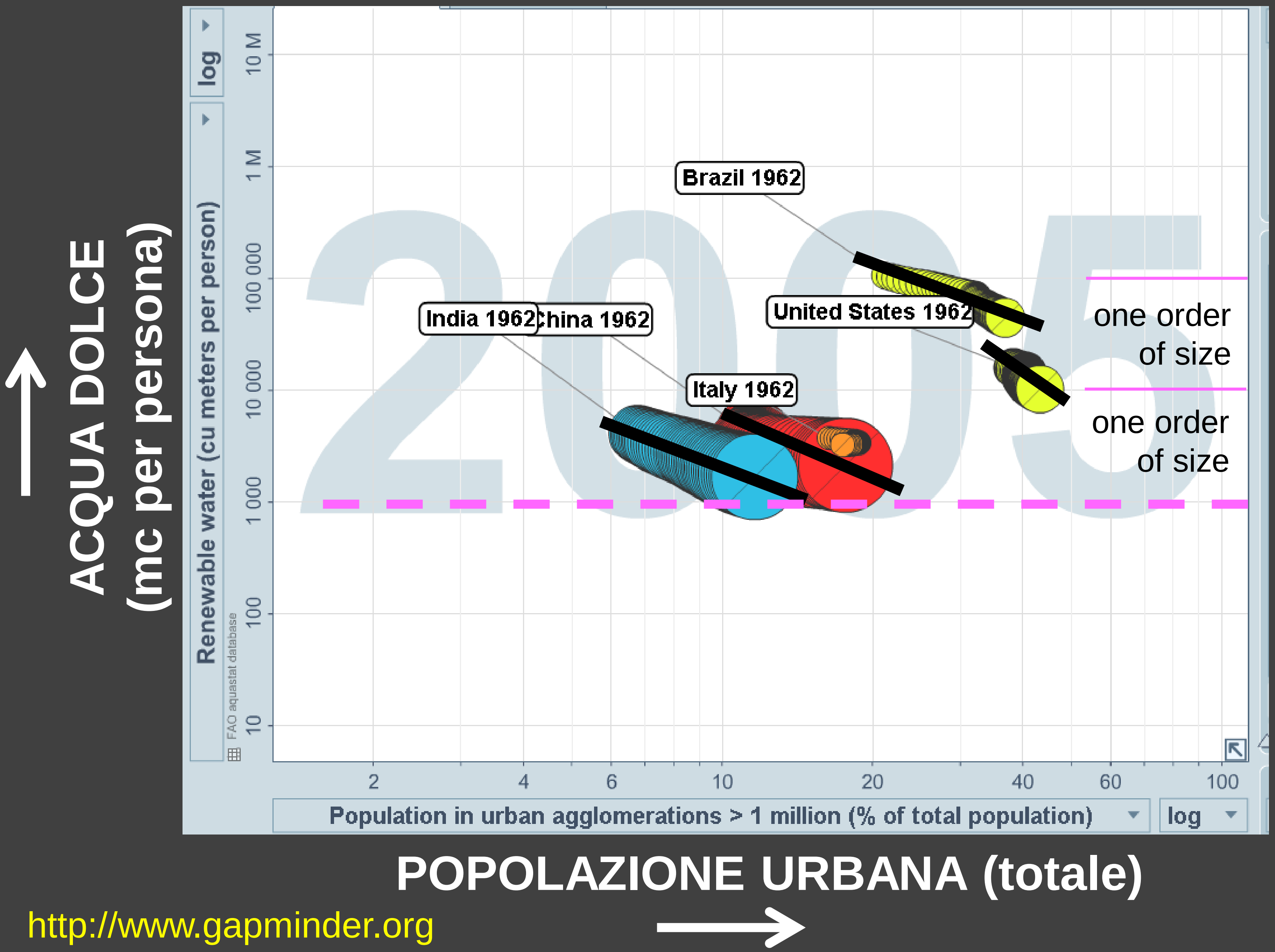




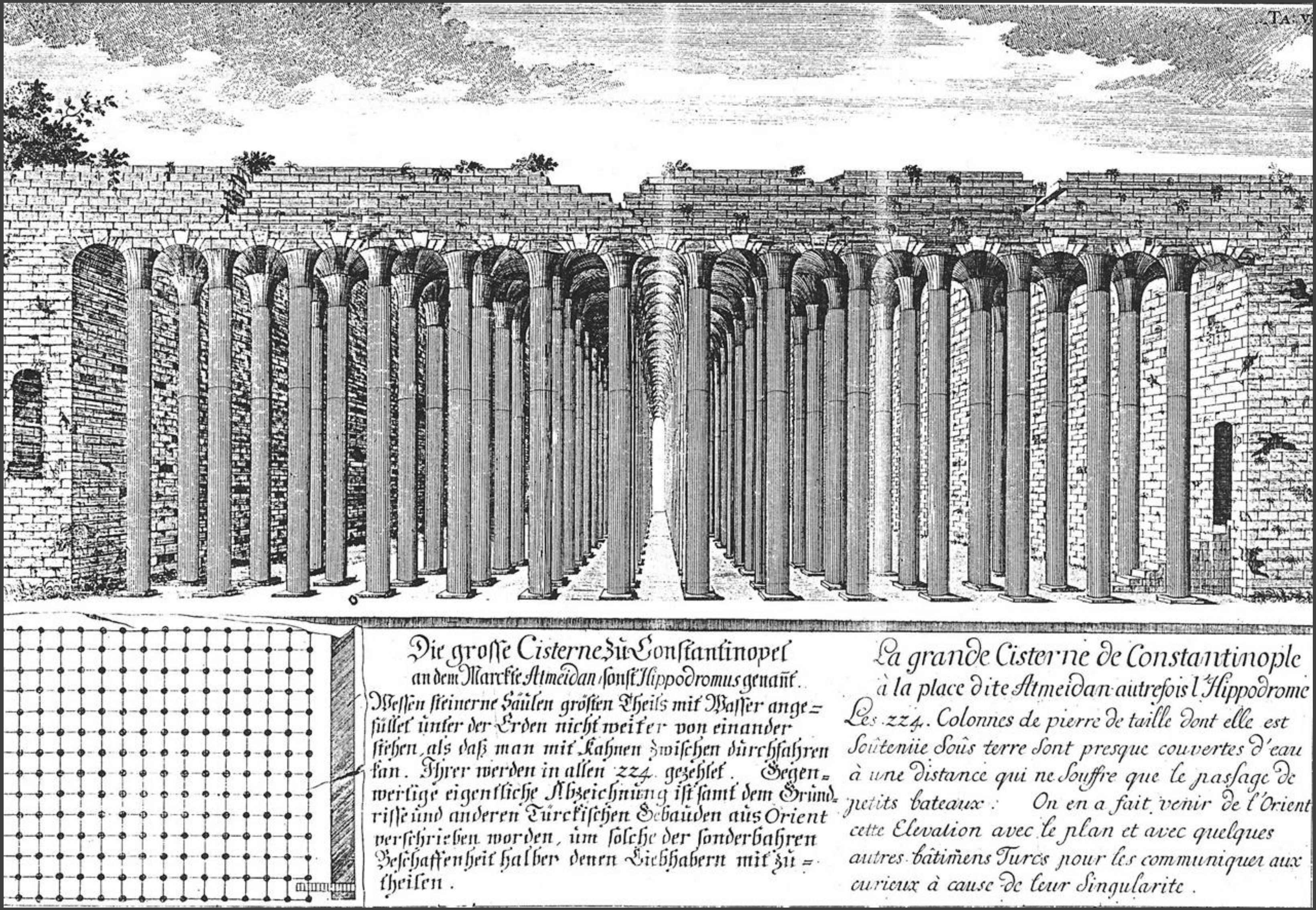
The potential increase of freshwater availability in the Indus river around the middle of the 21st century

The potential sudden decrease of freshwater availability in the Indus river by end of the 21st century


water and the city



http://www.gapminder.org

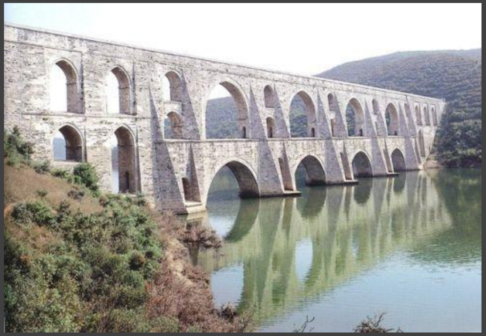

Die grosse Cisterne zu Constantinopel
an dem Marckte Atmeidan, sonst Hippodromus genant.
Wessen steinerne Säulen grösten Theils mit Wasser ange=
füllet unter der Erden nicht weiter von einander
stehen, als daß man mit Kahnen zwischen durchfahren
kan. Ihrer werden in allen 224. gezehlet. Gegen=
wertige eigentliche Abzeichnung ist samt dem Grund=
risse und anderen Türckischen Gebäuden aus Orient
verschrieben worden, um solche der sonderbahren
Beschaffenheit halber denen Liebhabern mit zu=
theilen.
La grande Cisterne de Constantinople
à la place dite Atmeidan autrefois l'Hippodrome
Les 224. Colonnes de pierre de taille dont elle est
Soûtenüe Soûs terre sont presque couvertes d'eau
à une distance qui ne souffre que le passage de
petits bateaux : On en a fait venir de l'Orient
cette Elevation avec le plan et avec quelques
autres bâtimens Turcs pour les communiquer aux
curieux à cause de leur Singularite.

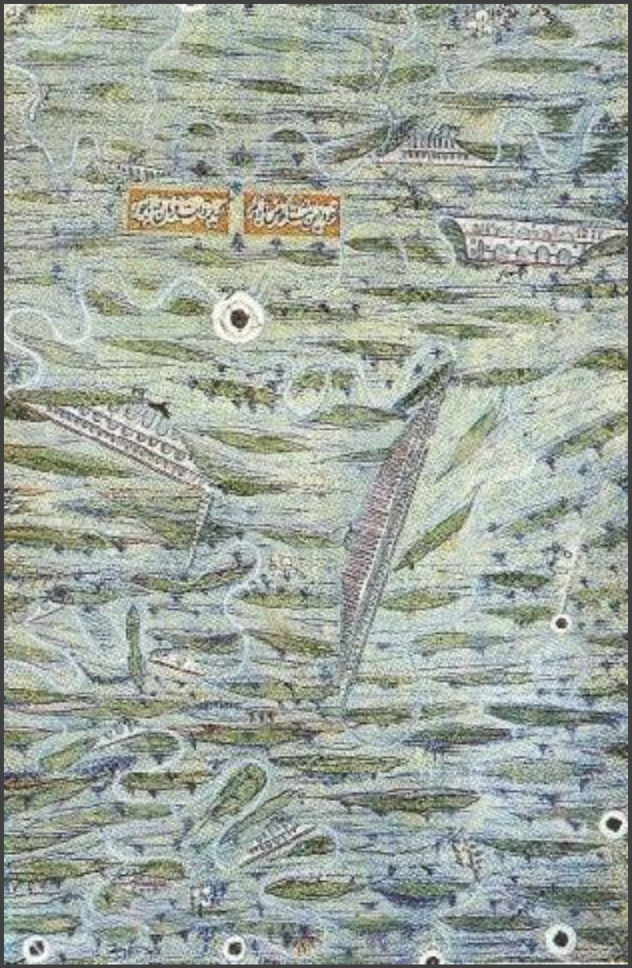

VALENS
AQUEDUCT
BLACK SEA
Basin
Dam
Archeological site
City
Istanbul city border
N
Elmalıdere
Alibey
Bentler
Kumköy
Rumelifeneri
Bosphorus
Gümüşpınar
Akalan
Yassıören
Sinekli
Büyükçekmece
Bentler
Sarıyer
Beykoz
Yeşilvadi
Şile
Yeşilçay
Kabakoz
Kemerburgaz
Yeniköy
Polonezköy
Alacalı
Teke
Büyükçekmece
Lake
Küçükçekmece
Istanbul
Taşdelen
Riva
Küçükçekmece
Bakırköy
Üsküdar
Ömerli
Darlık
Gök D.
Sungurlu
Yeşilköy
Elmalı
Isaköy
Kartal
İzmit
SEA OF MARMARA
Gulf of İzmit
20 km

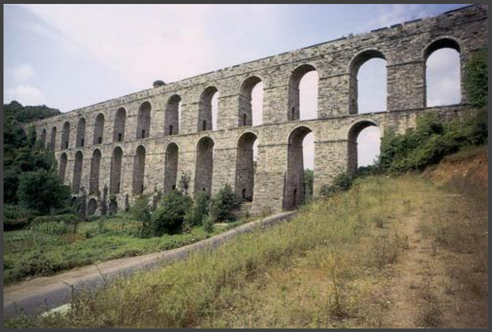
Kirkcesme water supply systems (1555-:- 1564)
Süleyman, Sultan, and **Sinan**, engineer and architect-in-chief

Uzunkemer Aqueduct

Maglova Aqueduct





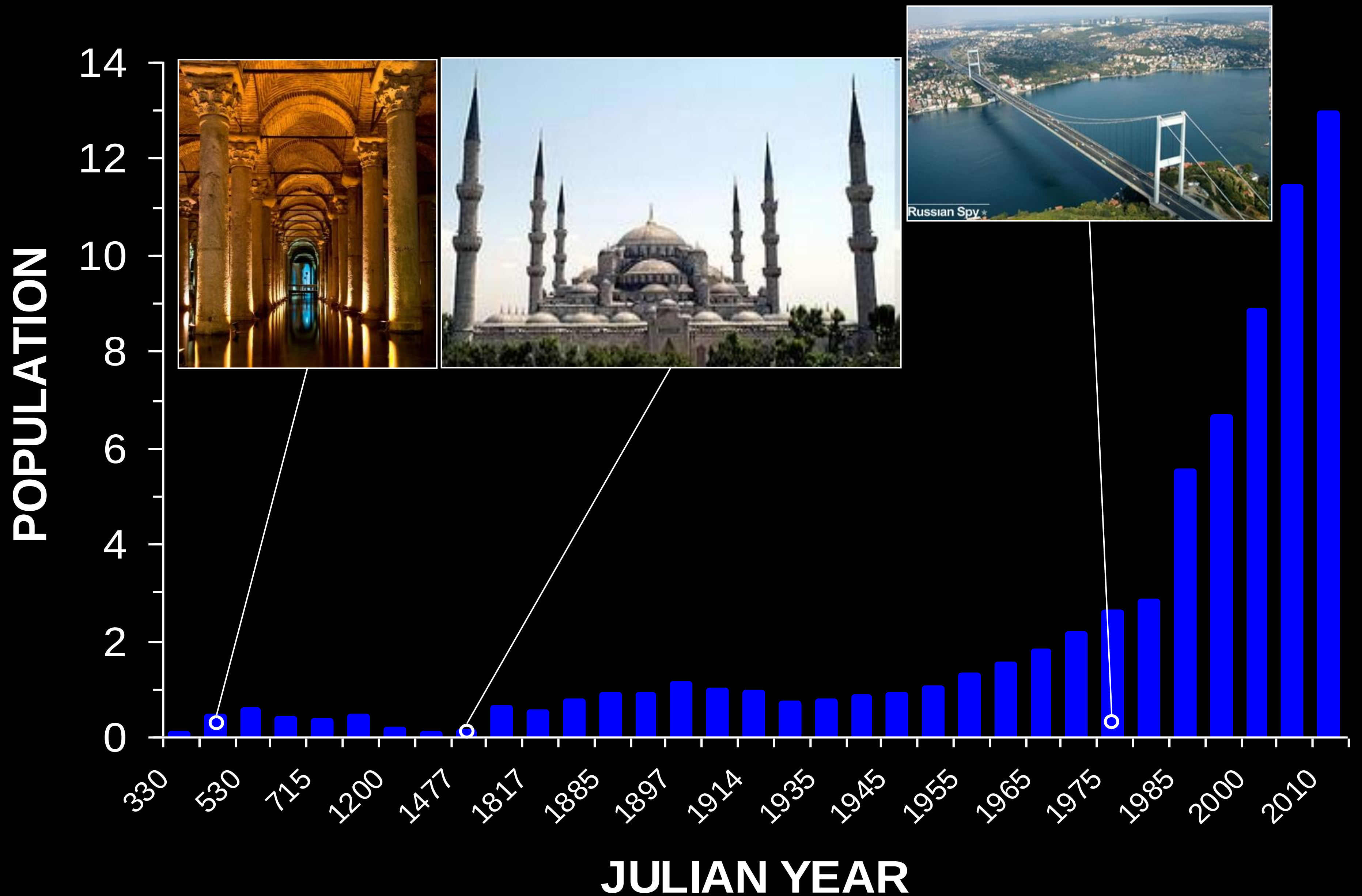


Egrikemer Aqueduct

Kovuk Aqueduct

La grande piscine à Brusa (The great bath at Bursa Turkey) - Jean-Leon Gerome (1885)

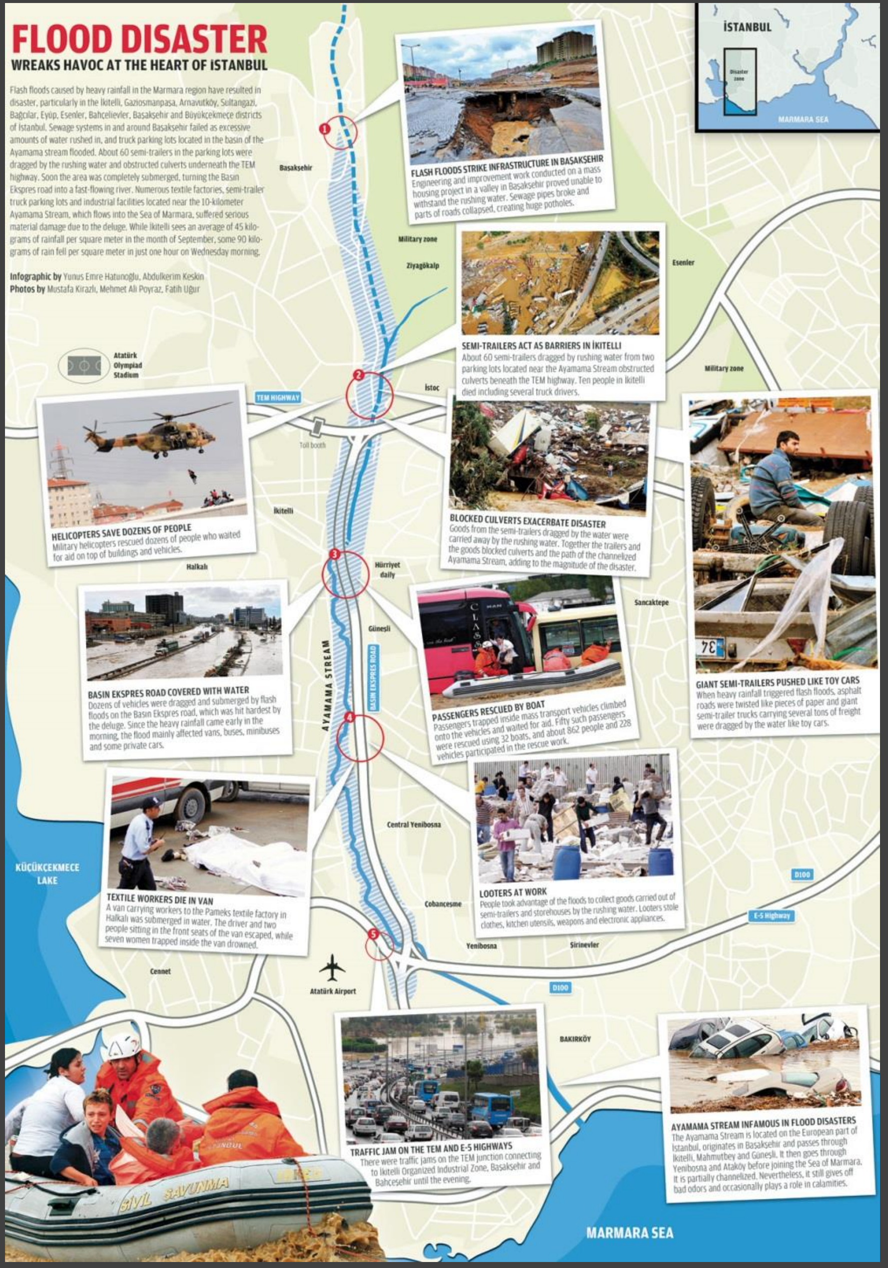

18462. P. Z. CONSTANTINOPLE. FONTAINE



Russian Spy
POPULATION
14
12
10
8
6
4
2
0
330
530
715
1200
1477
1817
1885
1897
1914
1935
1945
1955
1965
1975
1985
2000
2010
JULIAN YEAR


N
Elmalıdere
Çilingozdere
Kuzuludere
Düzdere
Yalıköy
Karacaköy
Ormanlı
Terkos
Lake Terkos
Sazlıdere
Alibey
Gümüşpınar
Bentler
Kumköy
Rumelifeneri
Bosphorus
GREAT MELEN PROJECT
Yeşilvadi
Akalan
Yassıören
Sinekli
Büyükçekmece
Bentler
Sarıyer
Şile
Kule
Çatalca
Kemerburgaz
Beykoz
Kabakoz
Yeşilçay
Ortaköy
Yeniköy
Polonezköy
Silivri
Lake Büyükçekmece
Büyükçekmece
Istanbul
Teke
Lake Küçükçekmece
Taşdelen
Kumburgaz
Küçükçekmece
Üsküdar
Ömerli
Riva
Gök D.
Sungurlu
Bakırköy
Darlık
Yeşilköy
Elmalı
Kartal
SEA OF MARMARA
İzmit
20 km
Basin
Dam
Archeological site
City
Istanbul city border


MELEN
PROJECT


FLOOD DISASTER
WREAKS HAVOC AT THE HEART OF İSTANBUL

Flash floods caused by heavy rainfall in the Marmara region have resulted in disaster, particularly in the İkitelli, Gaziosmanpaşa, Arnavutköy, Sultangazi, Bağcılar, Eyüp, Esenler, Bahçelievler, Başakşehir and Büyükçekmeçe districts of İstanbul. Sewage systems in and around Başakşehir failed as excessive amounts of water rushed in, and truck parking lots located in the basin of the Ayamama stream flooded. About 60 semi-trailers in the parking lots were dragged by the rushing water and obstructed culverts underneath the TEM highway. Soon the area was completely submerged, turning the Basın Ekspres road into a fast-flowing river. Numerous textile factories, semi-trailer truck parking lots and industrial facilities located near the 10-kilometer Ayamama Stream, which flows into the Sea of Marmara, suffered serious material damage due to the deluge. While İkitelli sees an average of 45 kilograms of rainfall per square meter in the month of September, some 90 kilograms of rain fell per square meter in just one hour on Wednesday morning.

Infographic by Yunus Emre Hatunoğlu, Abdulkerim Keskin
Photos by Mustafa Kirazlı, Mehmet Ali Poyraz, Fatih Uğur

FLASH FLOODS STRIKE INFRASTRUCTURE IN BAŞAKŞEHIR
Engineering and improvement work conducted on a mass housing project in a valley in Başakşehir proved unable to withstand the rushing water. Sewage pipes broke and parts of roads collapsed, creating huge potholes.

SEMI-TRAILERS ACT AS BARRIERS IN İKITELLI
About 60 semi-trailers dragged by rushing water from two parking lots located near the Ayamama Stream obstructed culverts beneath the TEM highway. Ten people in İkitelli died including several truck drivers.

HELICOPTERS SAVE DOZENS OF PEOPLE
Military helicopters rescued dozens of people who waited for aid on top of buildings and vehicles.

BLOCKED CULVERTS EXACERBATE DISASTER
Goods from the semi-trailers dragged by the water were carried away by the rushing water. Together the trailers and the goods blocked culverts and the path of the channelized Ayamama Stream, adding to the magnitude of the disaster.

GIANT SEMI-TRAILERS PUSHED LIKE TOY CARS
When heavy rainfall triggered flash floods, asphalt roads were twisted like pieces of paper and giant semi-trailer trucks carrying several tons of freight were dragged by the water like toy cars.

BASIN EKSPRES ROAD COVERED WITH WATER
Dozens of vehicles were dragged and submerged by flash floods on the Basın Ekspres road, which was hit hardest by the deluge. Since the heavy rainfall came early in the morning, the flood mainly affected vans, buses, minibuses and some private cars.

PASSENGERS RESCUED BY BOAT
Passengers trapped inside mass transport vehicles climbed onto the vehicles and waited for aid. Fifty such passengers were rescued using 32 boats, and about 862 people and 228 vehicles participated in the rescue work.

TEXTILE WORKERS DIE IN VAN
A van carrying workers to the Pameks textile factory in Halkalı was submerged in water. The driver and two people sitting in the front seats of the van escaped, while seven women trapped inside the van drowned.

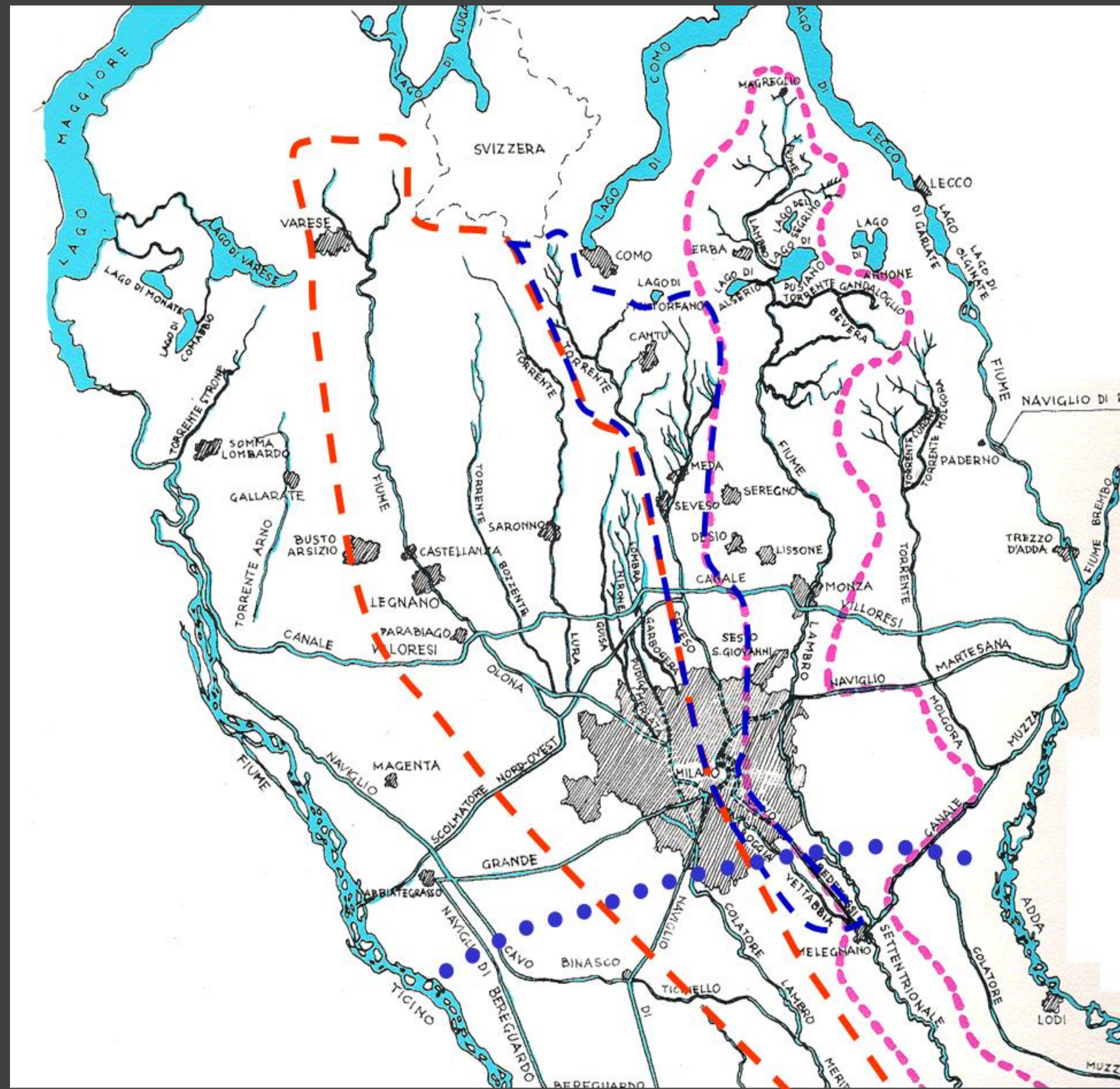
LOOTERS AT WORK
People took advantage of the floods to collect goods carried out of semi-trailers and storehouses by the rushing water. Looters stole clothes, kitchen utensils, weapons and electronic appliances.

TRAFFIC JAM ON THE TEM AND E-5 HIGHWAYS
There were traffic jams on the TEM junction connecting to İkitelli Organized Industrial Zone, Başakşehir and Bahçeşehir until the evening.

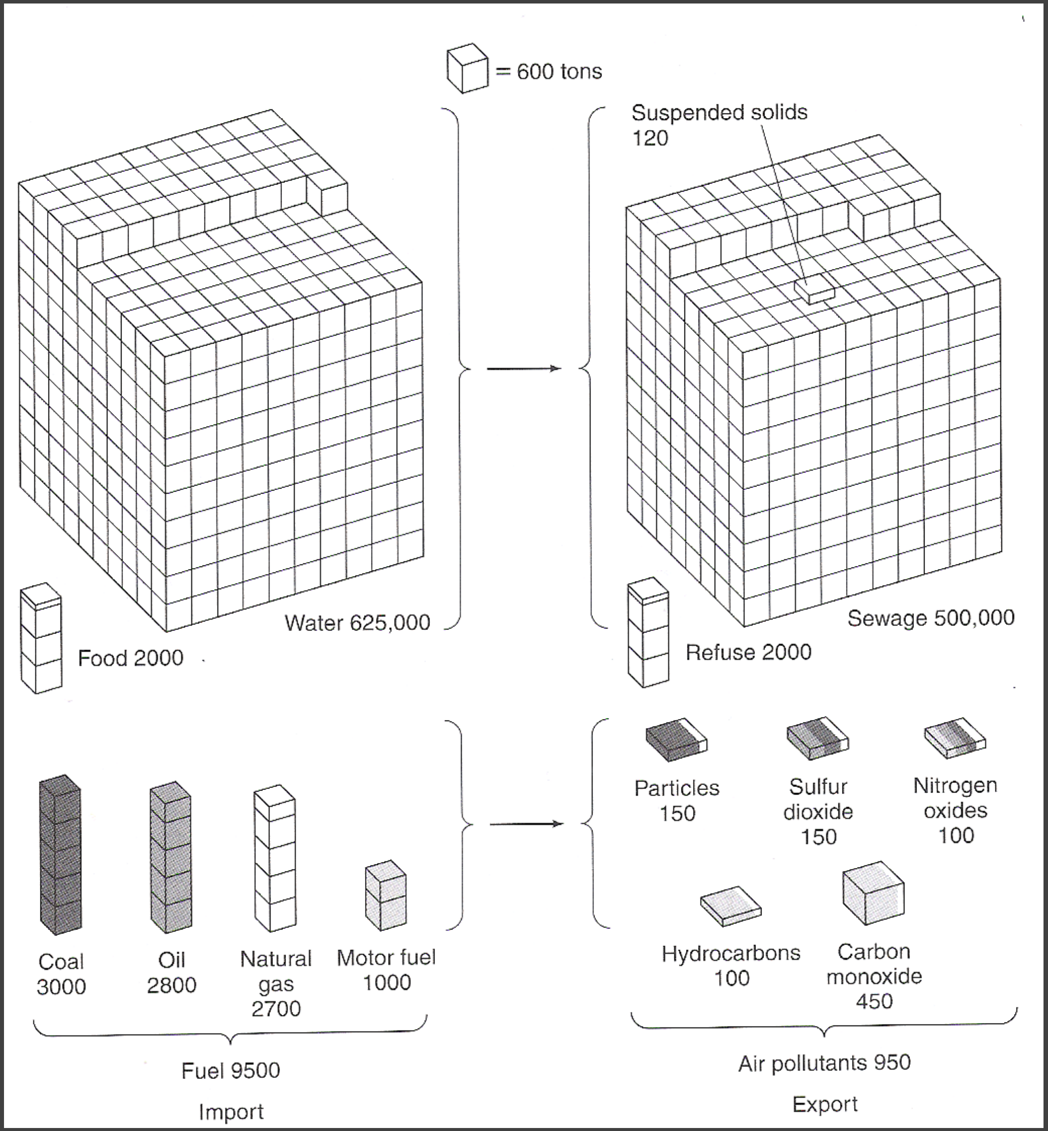
AYAMAMA STREAM INFAMOUS IN FLOOD DISASTERS
The Ayamama Stream is located on the European part of İstanbul, originates in Başakşehir and passes through İkitelli, Mahmutbey and Güneşli. It then goes through Yenibosna and Ataköy before joining the Sea of Marmara. It is partially channelized. Nevertheless, it still gives off bad odors and occasionally plays a role in calamities.

The metropolitan area of Milan, Italy, displays a complex surface water network, this including rivers and minor streams, and a lot of artificial channels that were build across the centuries in order to trasfer water from one drainage basin to another, to supply irrigation facilities, and to provide trasnsportation routes.

This network, starting from the 10° and 11° century, includes the Navigli, a complex system contributed by Leonardo da Vinci among others



Water is a fundamental component of mass balance of a city



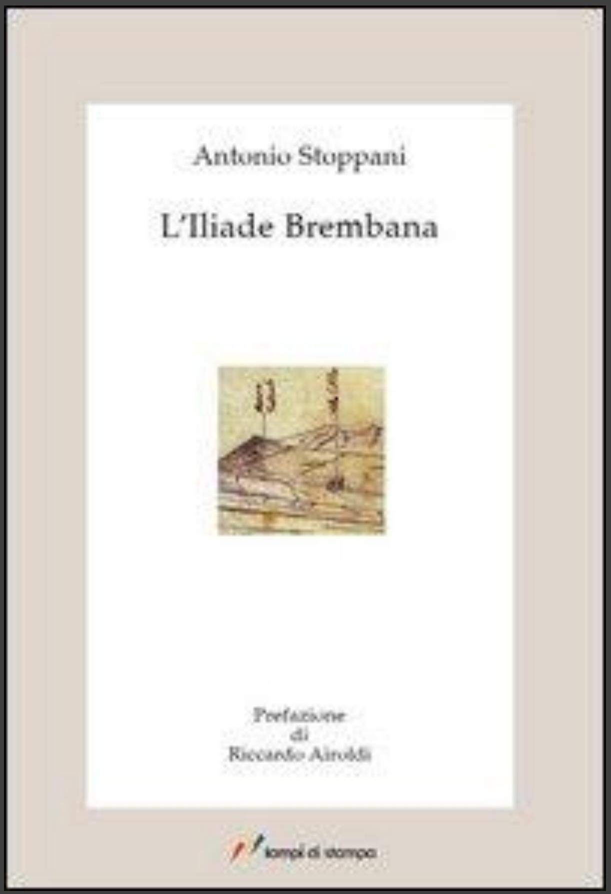
in downtown Milan:

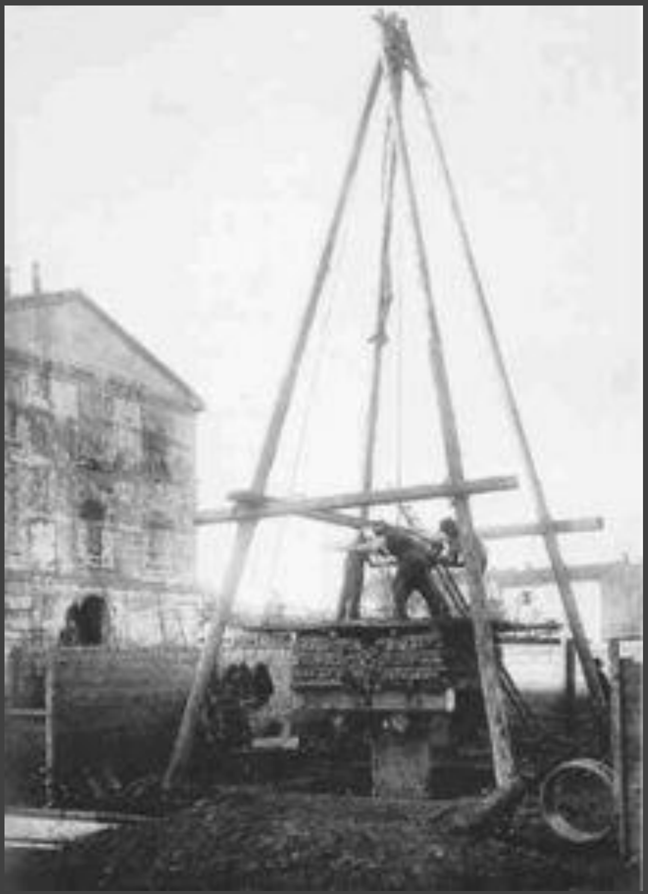
$450 \times 10^6\ m^3$

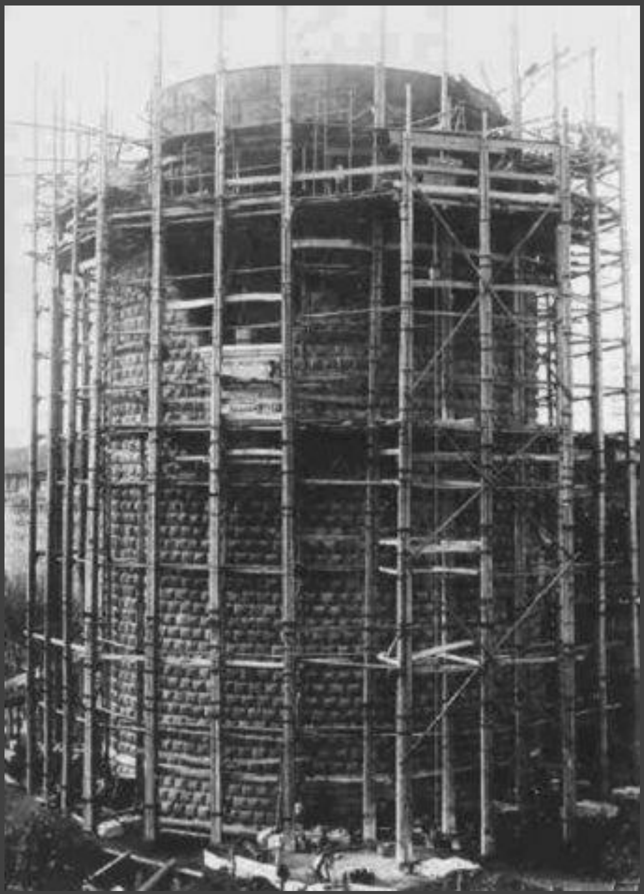
47% groundewater supply

53% areal precipitation

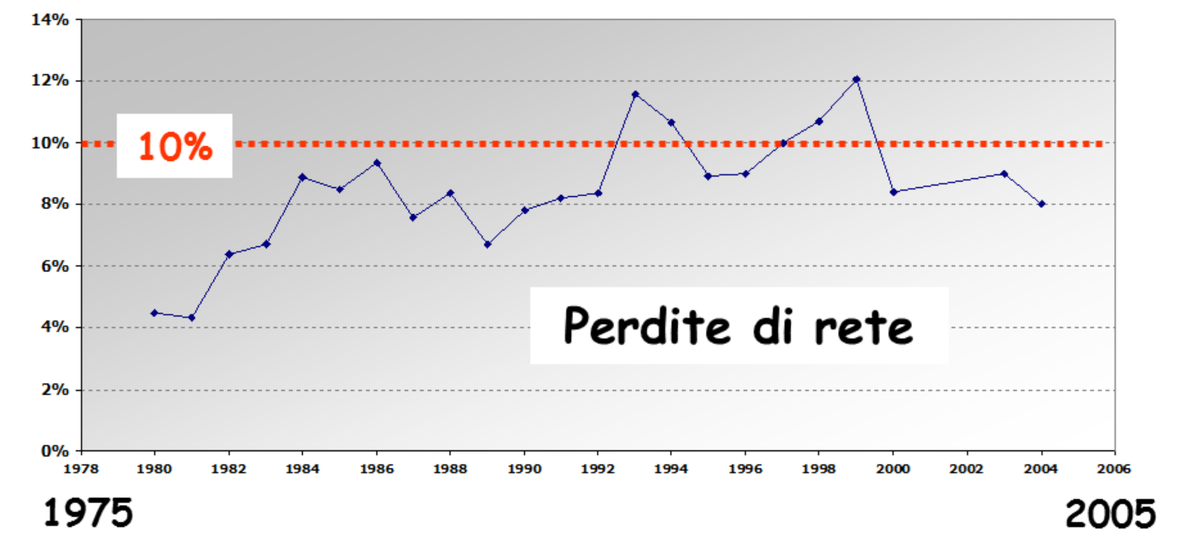
Bonvesin della Riva
reports that
in year 1200
there were 6.000 wells
of "acqua viva" ,
i.e freshwater,
in the area of Milan

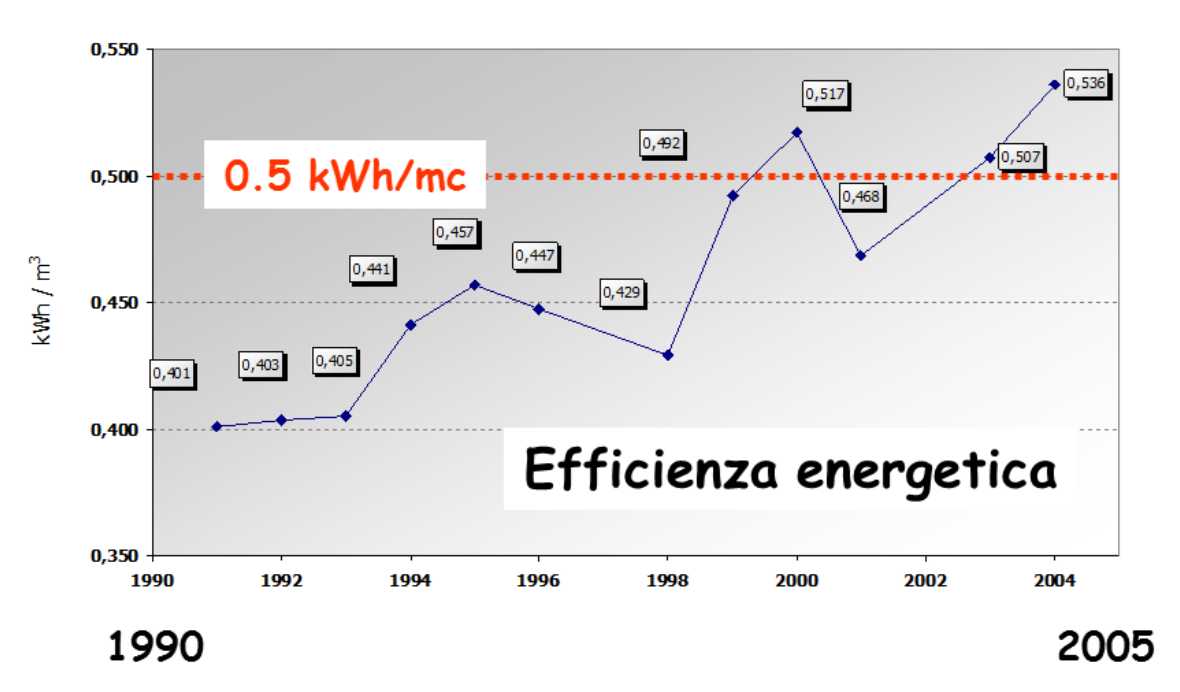

Antonio Stoppani
L'Iliade Brembana
Prefazione
di
Riccardo Airoldi
lampi di stampa

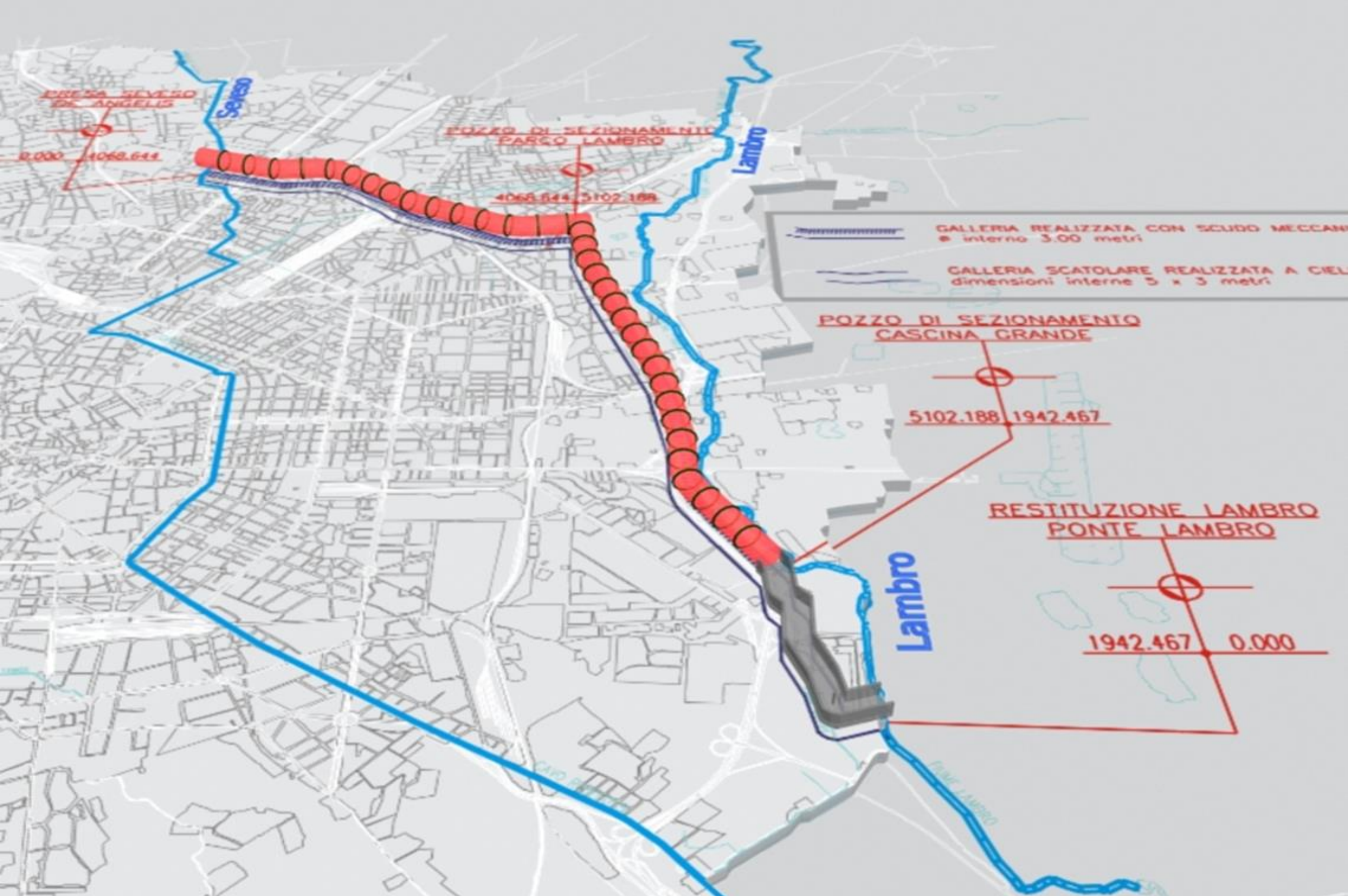




Nowadays, the (downtown) Milan city-acqueduct relies on 550 wells that are located inside a circle of about 10 kilometers in radius


14%
12%
10%
8%
6%
4%
2%
0%
10%
Perdite di rete
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
1975
2005


0,550
0,500
0,450
0,400
0,350
kWh / m3
0.5 kWh/mc
0,401
0,403
0,405
0,441
0,457
0,447
0,429
0,492
0,517
0,468
0,507
0,536
Efficienza energetica
1990
1992
1994
1996
1998
2000
2002
2004
1990
2005


Seveso
PRESA SEVESO DE ANGELIS
0.000 4068.644
POZZO DI SEZIONAMENTO PARCO LAMBRO
4068.644 5102.188
Lambro
dimensioni interne 5 x 3 metri
POZZO DI SEZIONAMENTO CASCINA GRANDE
5102.188 1942.467
RESTITUZIONE LAMBRO PONTE LAMBRO
1942.467 0.000
Lambro

STUDIO DI FATTIBILITA' DELLA RIAPERTURA DEI NAVIGLI MILANESI NELL'AMBITO DELLA RIATTIVAZIONE DEL SISTEMA COMPLESSIVO DEI NAVIGLI E DELLA SUA NAVIGABILITA'

Progetto coordinato da Antonello Boatti

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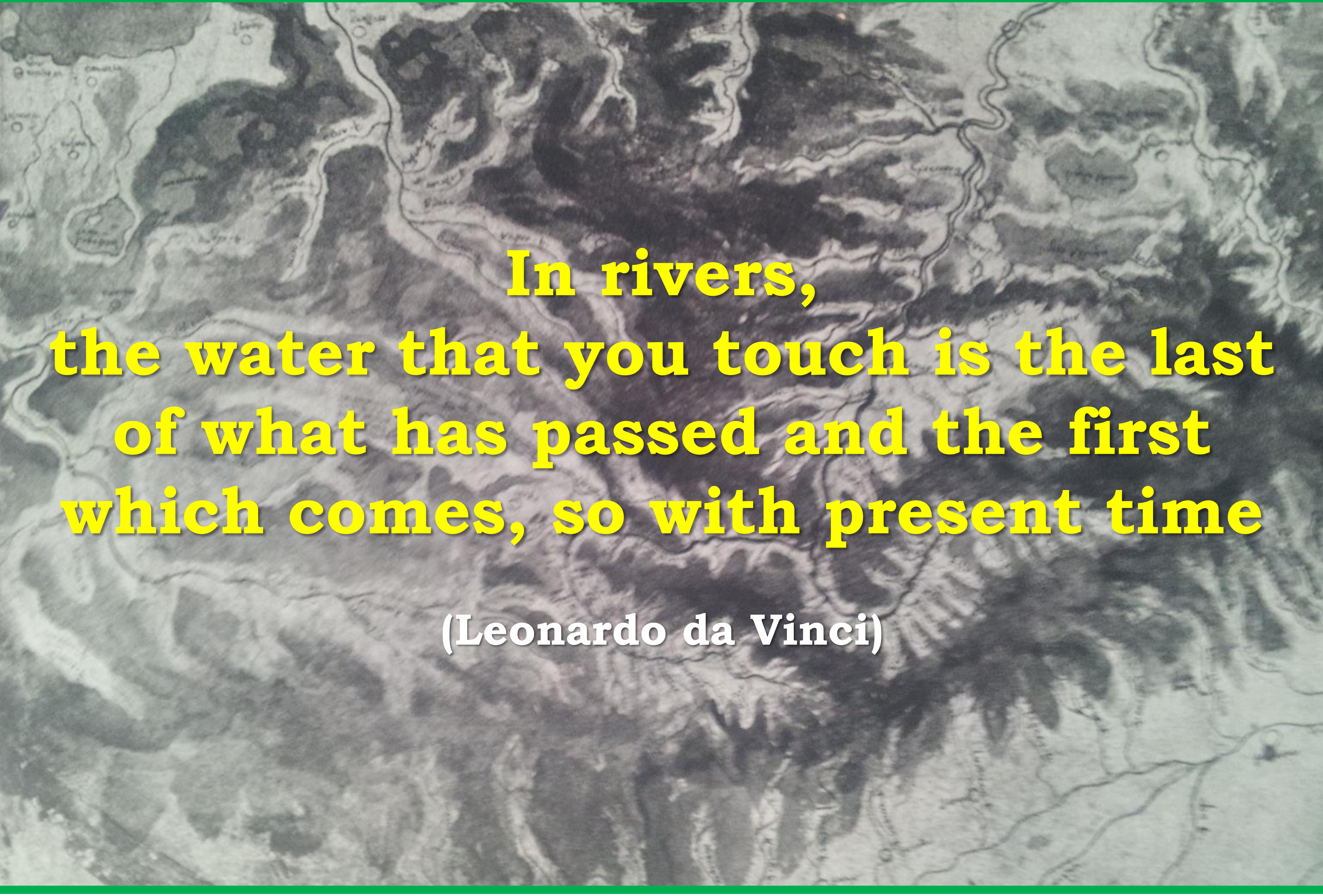
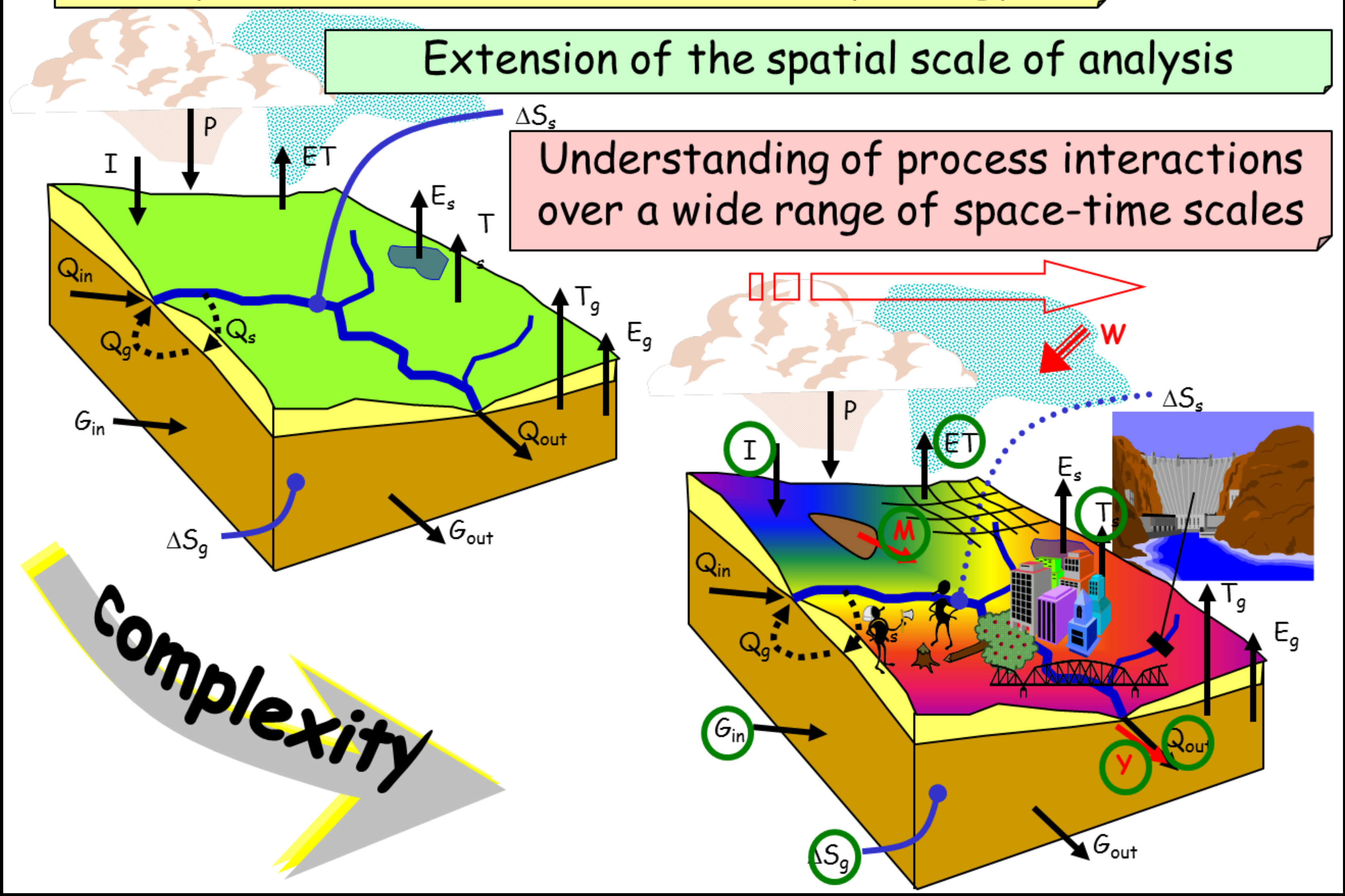


In rivers,
the water that you touch is the last of what has passed and the first which comes, so with present time

(Leonardo da Vinci)

Expansion of Process Variables in Hydrology



expansion of process variables

Modern hydrology is an observational science originated after the late XVII century confutation of current theories on springs and river origin. The basic understanding was

1. that one must consider a combination of physical processes – i.e. precipitation, infiltration, transpiration, evaporation, and diversion, not only flow – to explain runoff and its variability at a river site

extension of the spatial scale of analysis

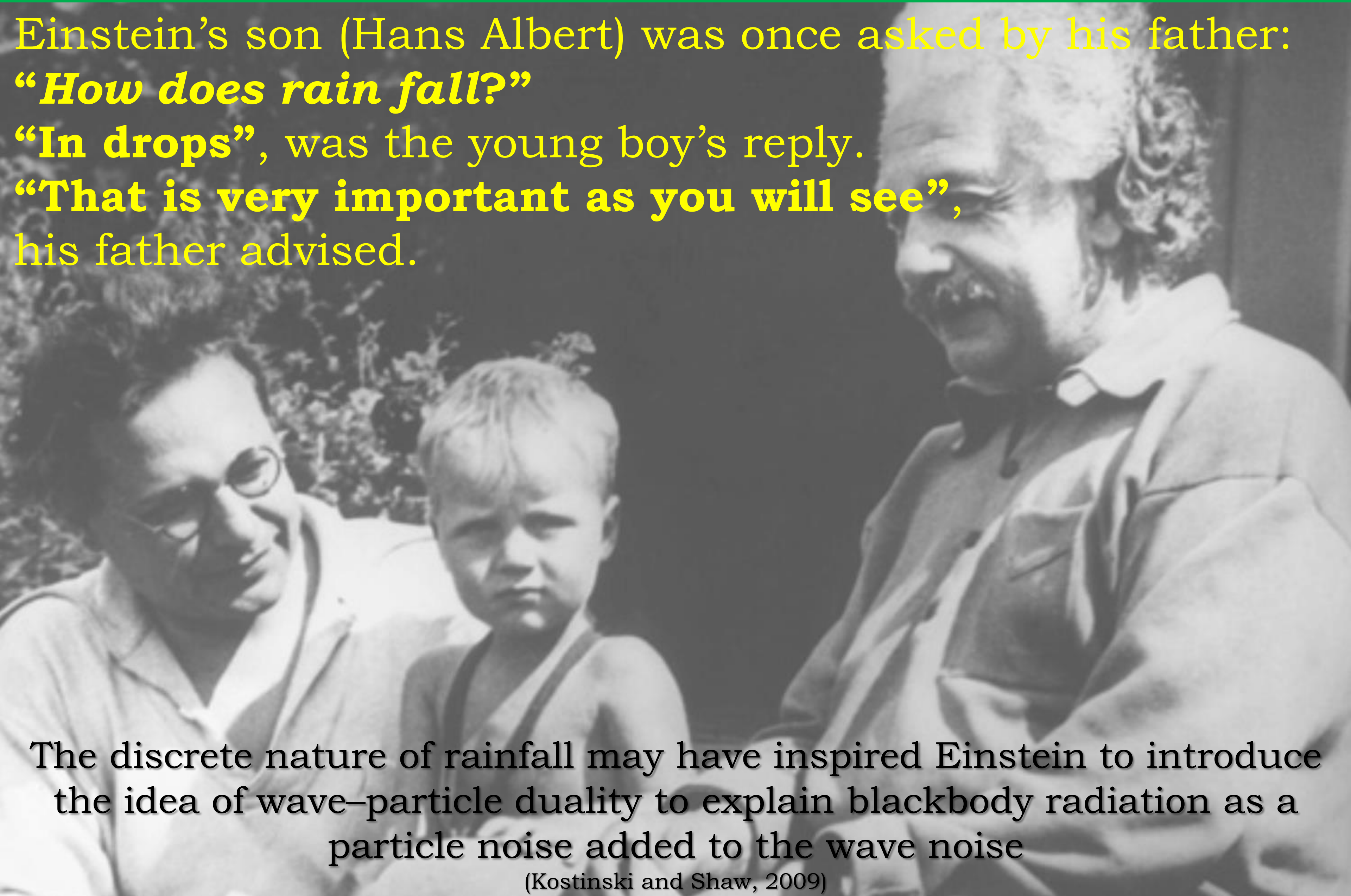
Modern hydrology is an observational science originated after the late XVII century confutation of current theories on springs and river origin. The basic understanding was

2. that one must consider a much larger spatial scale – i.e. the drainage basin instead of a river cross-section – to explain runoff and its variability at a river site

understanding of process interactions over a wide range of space-time scales

Modern hydrology is an observational science originated after the late XVII century confutation of current theories on springs and river origin. The basic understanding was

3. that one must consider process interactions – i .e. precipitation, infiltration, transpiration, evaporation, impounding and diversion – over a wide range of spatial and temporal scales – i.e. from a plot or a river transect to a creek and the watershed to explain runoff and its variability at a river site



Einstein's son (Hans Albert) was once asked by his father:
"*How does rain fall?*"
"In drops", was the young boy's reply.
"That is very important as you will see",
his father advised.

The discrete nature of rainfall may have inspired Einstein to introduce the idea of wave–particle duality to explain blackbody radiation as a particle noise added to the wave noise
(Kostinski and Shaw, 2009)

a large scale system can differ from the sum of its individual components:
a forest is not just a collection of trees

(Fred I. Morton)

nobody accepts the model as true,
except
who built the model

everyone accepts the data as true,
except
who collected the data

(Gaylon S. Campbell)

Hydrology has developed slowly because it has been considered an appendage of hydraulic engineering rather than a natural science.

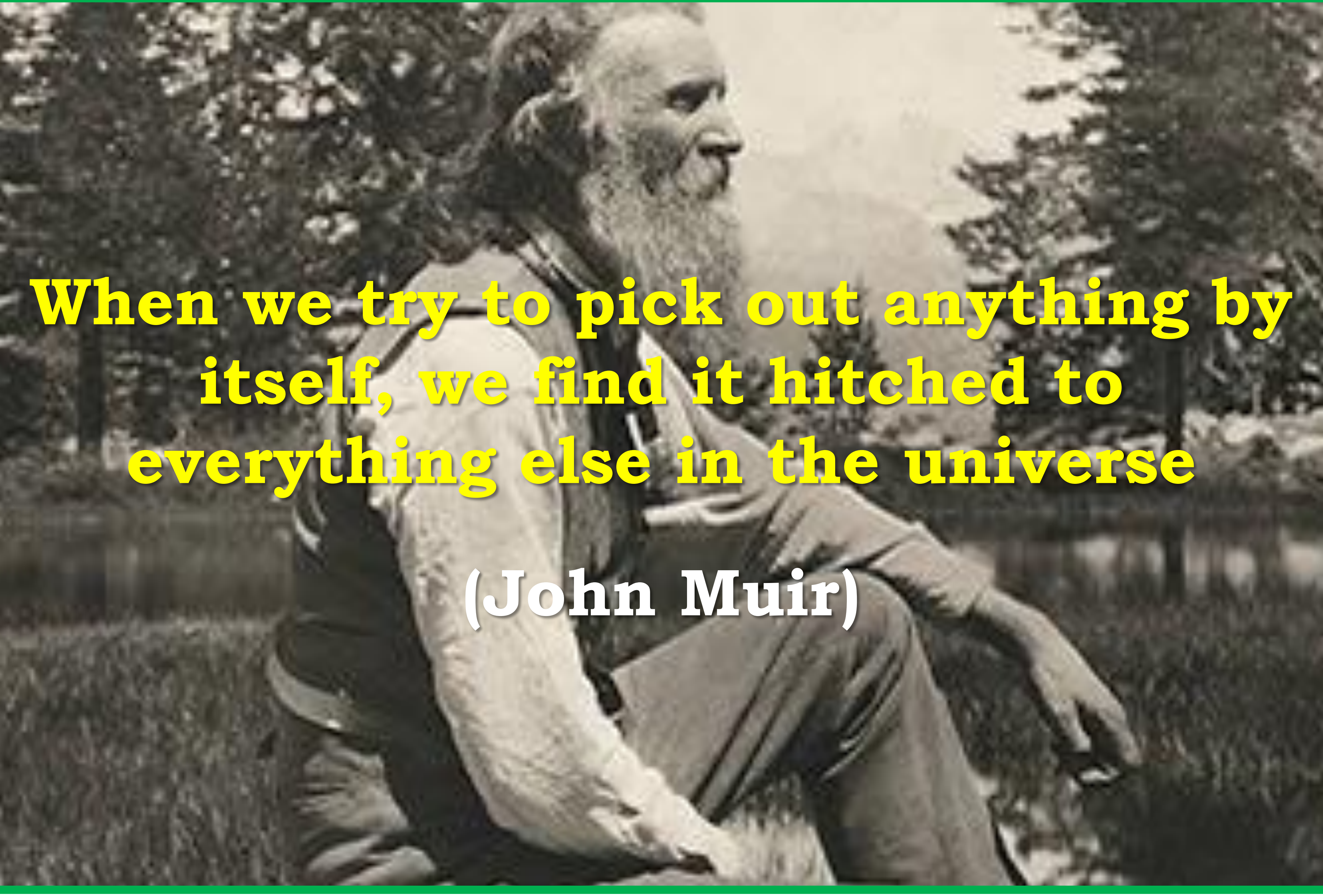
Vujica Yevievich
1968

In practice, hydrology is regarded mostly as a technological discipline rather than a science; this attitude is responsible for much bad science in hydrology which, in turn, has led to much bad technology in applied disciplines.

Vito Klemes
1988

Some one is going to…end up with an understanding of the relation of the physical basis for statistical variability in time and space.

David R. Dawdy
2008


When we try to pick out anything by itself, we find it hitched to everything else in the universe
(John Muir)

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thanks for attention