Five Global Grand Challenges

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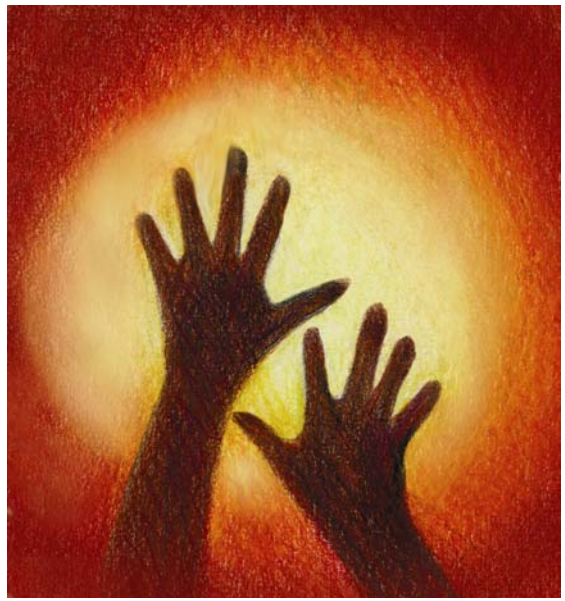
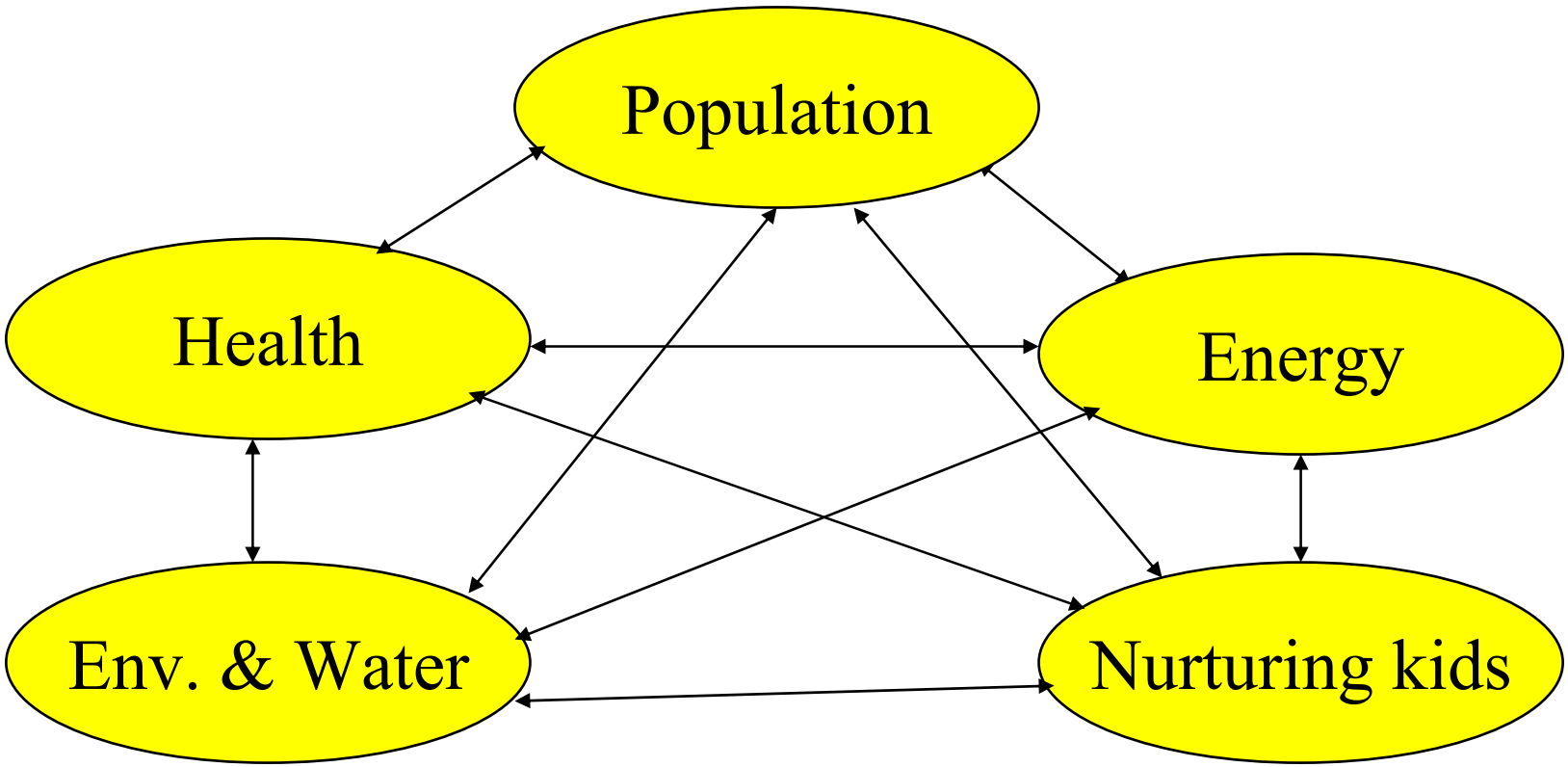


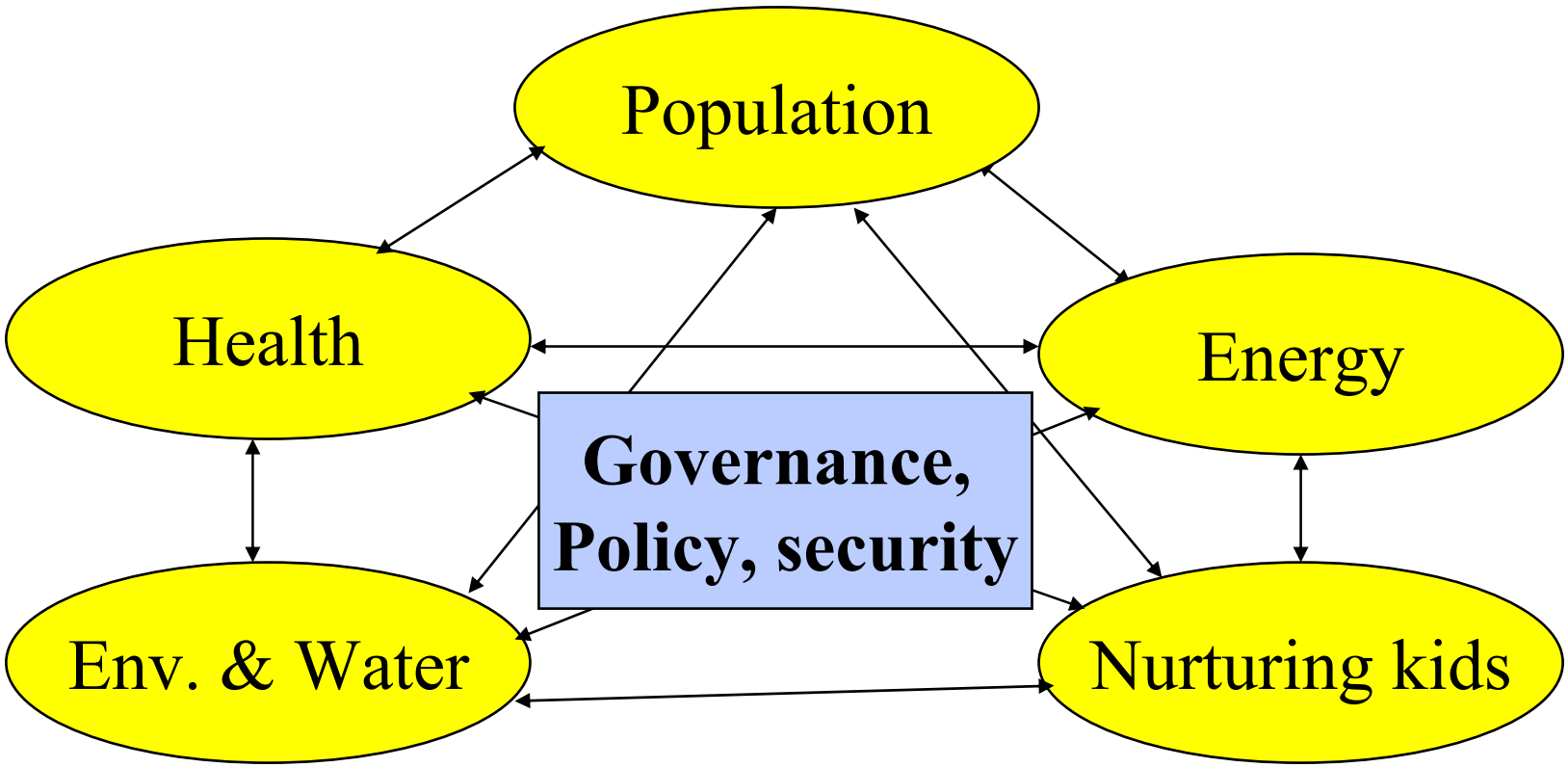
5 grand challenges: my perspective

- Population (aging, growth, migration)
- Global public health
  - Essential vaccines, medicines, services for all
- Cheap clean energy for all
- Managing the environment & water resources
- Nurturing and educating kids for 0-22+ years

System of strongly coupled, complex, non-linear systems & networks under stress



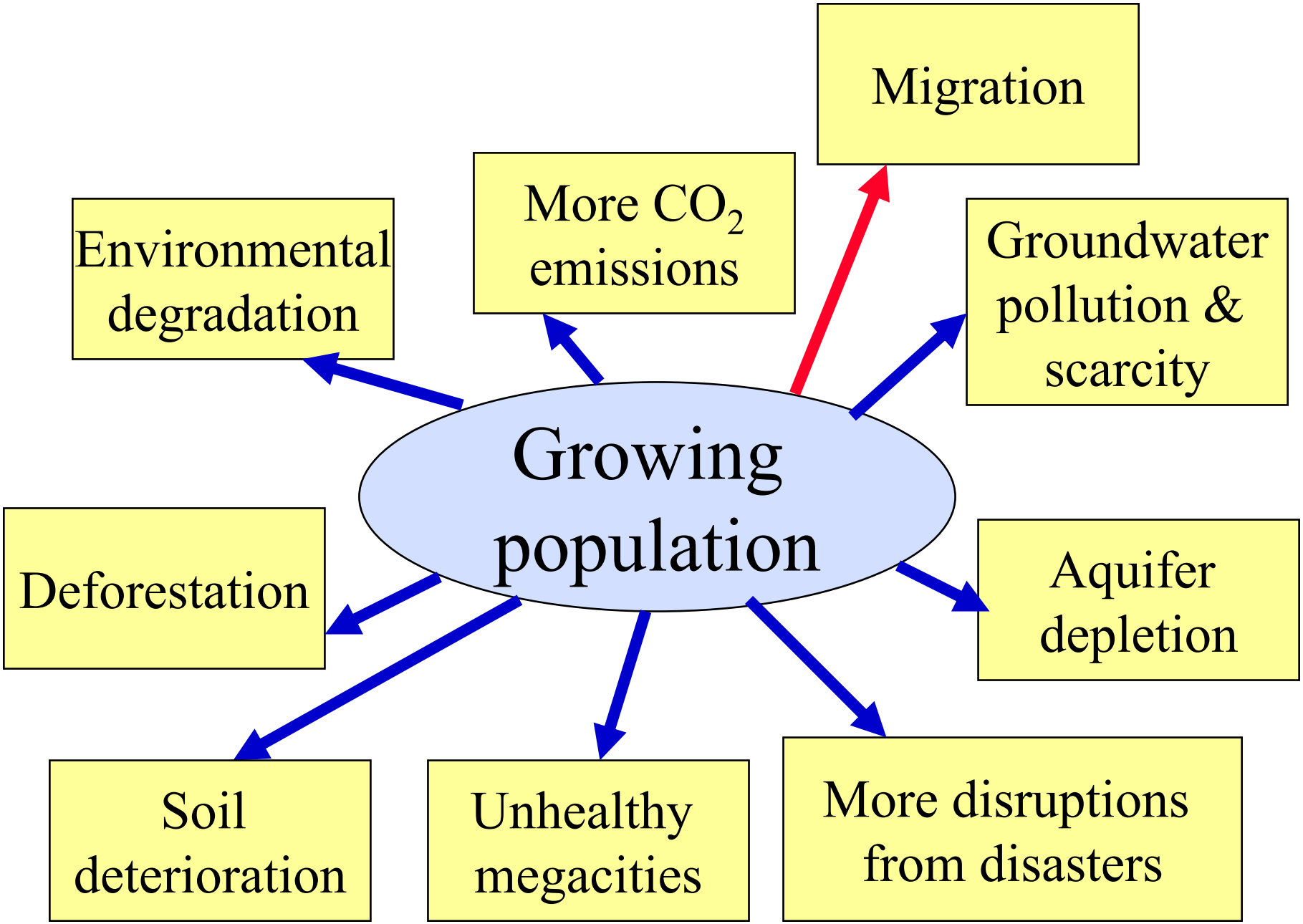
Need public-private partnership & global vision. Must address all five



1) Population

Aging/Growing/Migrating populations

- Industrialized world faces aging and decline in fertility $\rightarrow$ less working people (TFR < 2.1)
- Poor and developing countries have growing populations and rapid haphazard urbanization
- Mass migrations and shifts can create tensions
- Demand for resources grows "linearly" with population in each income group, but impact on environment can be highly non-linear
- Geographical distribution, inequalities, nature of urbanization are important determinants of impact


Migration
More CO_2 emissions
Environmental degradation
Groundwater pollution & scarcity
Growing population
Deforestation
Aquifer depletion
Soil deterioration
Unhealthy megacities
More disruptions from disasters

Aging

Senior citizens need

- **Emotional and physical support**
- **Health care with rising costs**
- **Security (physical, financial, emotional)**

Foster lifelong healthy lifestyles to prolong productive life and reduce above burdens

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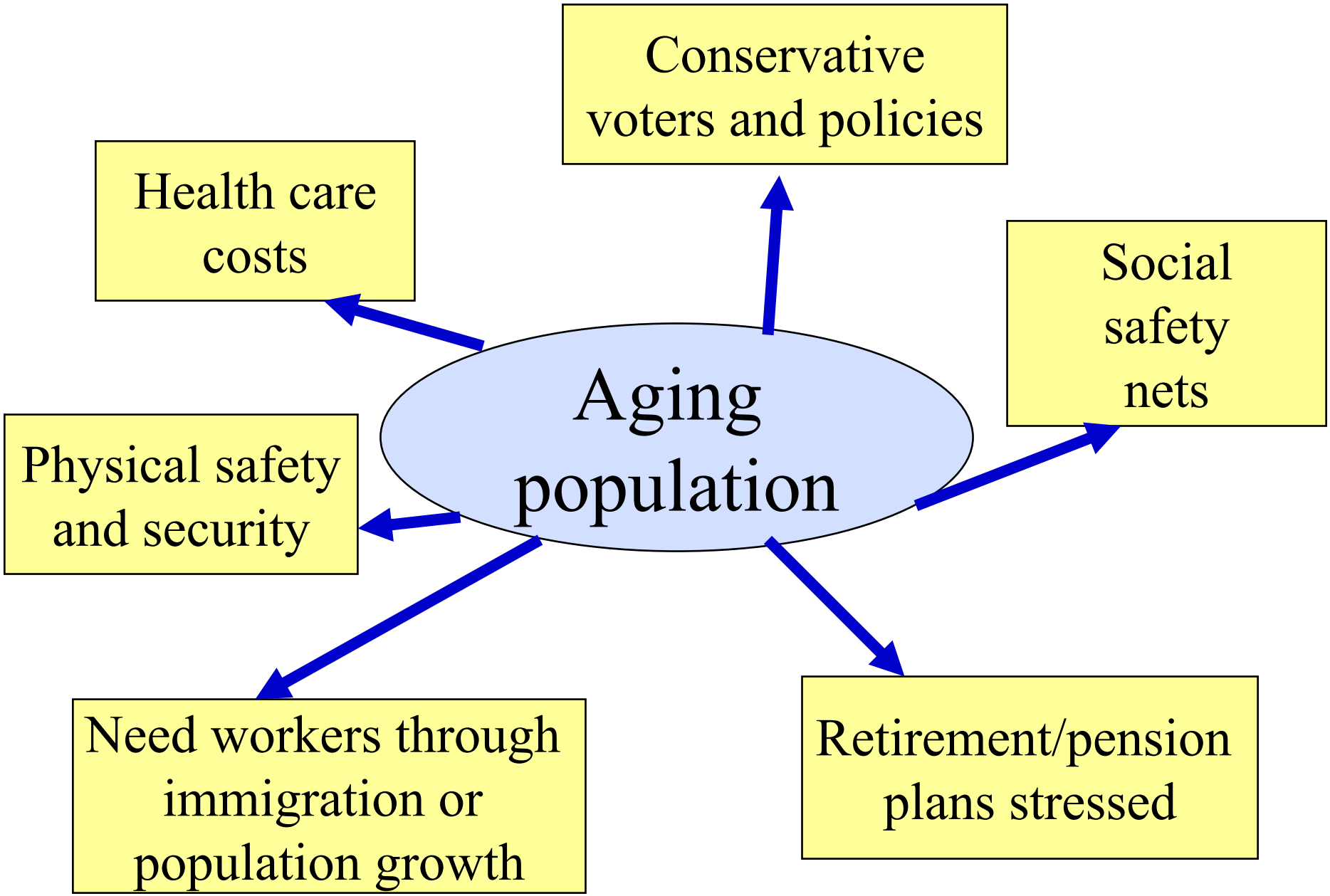
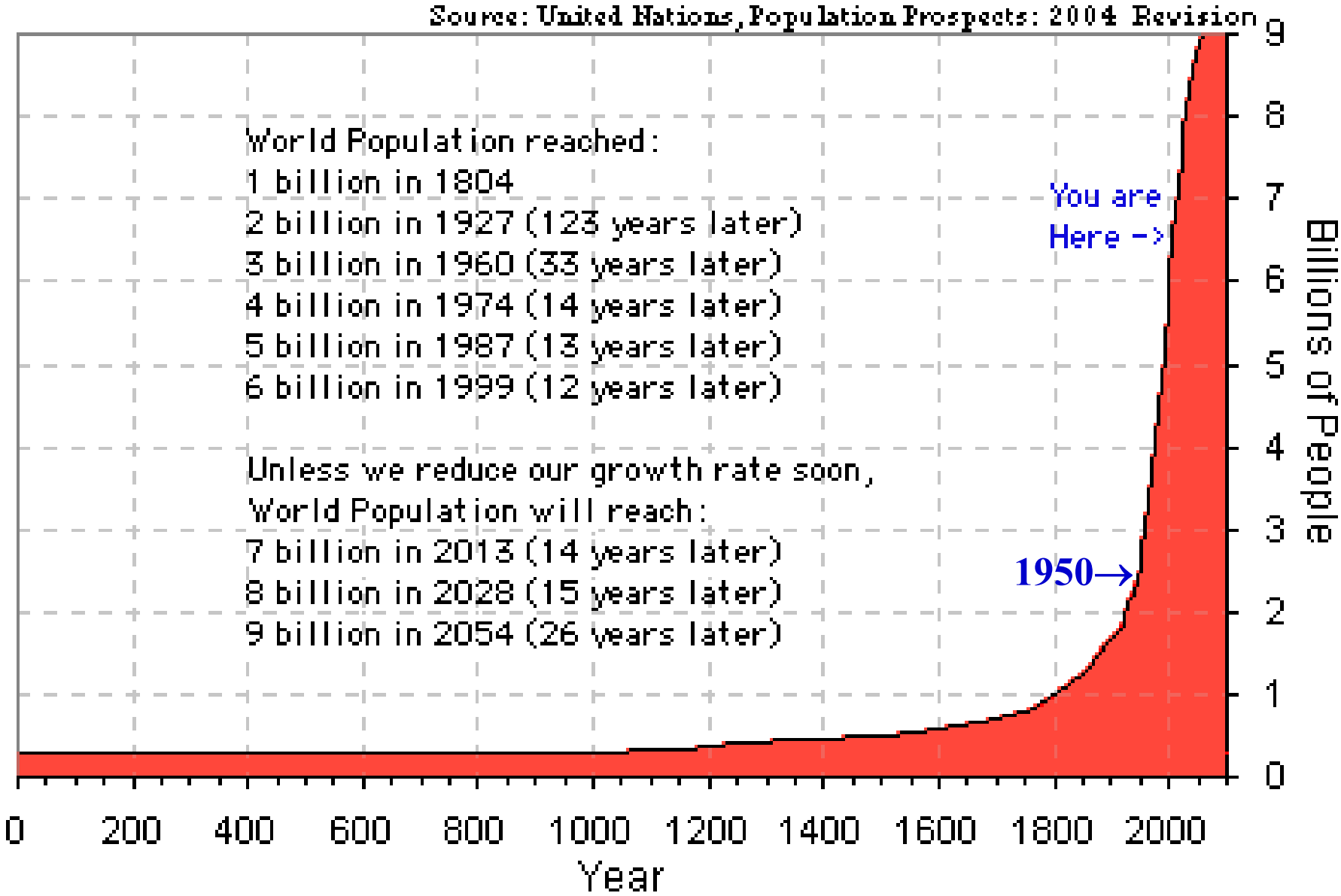
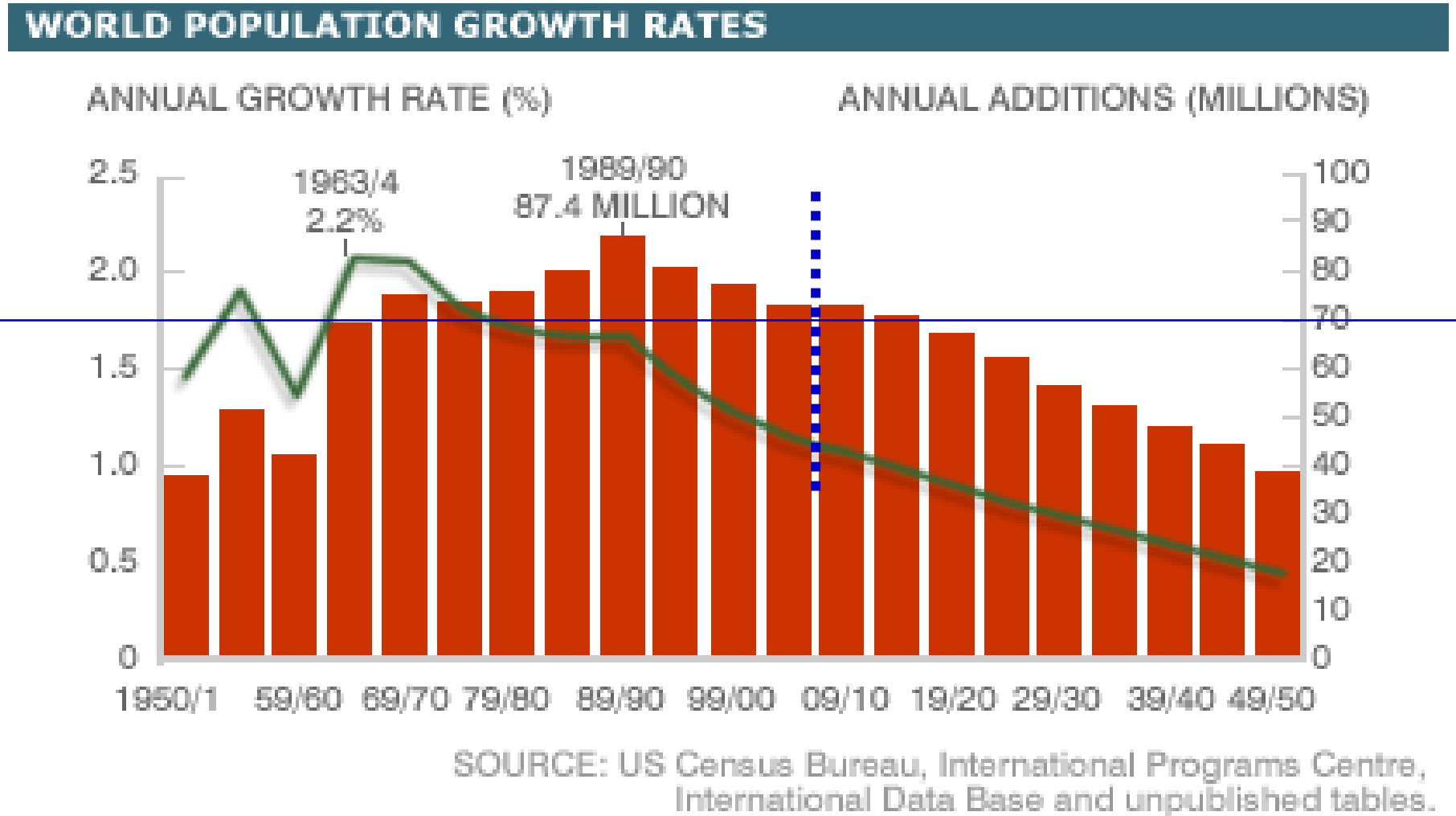
Priorities of this voting block are different


Conservative voters and policies
Health care costs
Social safety nets
Aging population
Physical safety and security
Need workers through immigration or population growth
Retirement/pension plans stressed

Population Growth





Population Reference Bureau

A macro view of global population

2 billion in 21st century

Resources & Skills

1.5B people in transition

3 billion in 18th century with less than $2 ppp/day

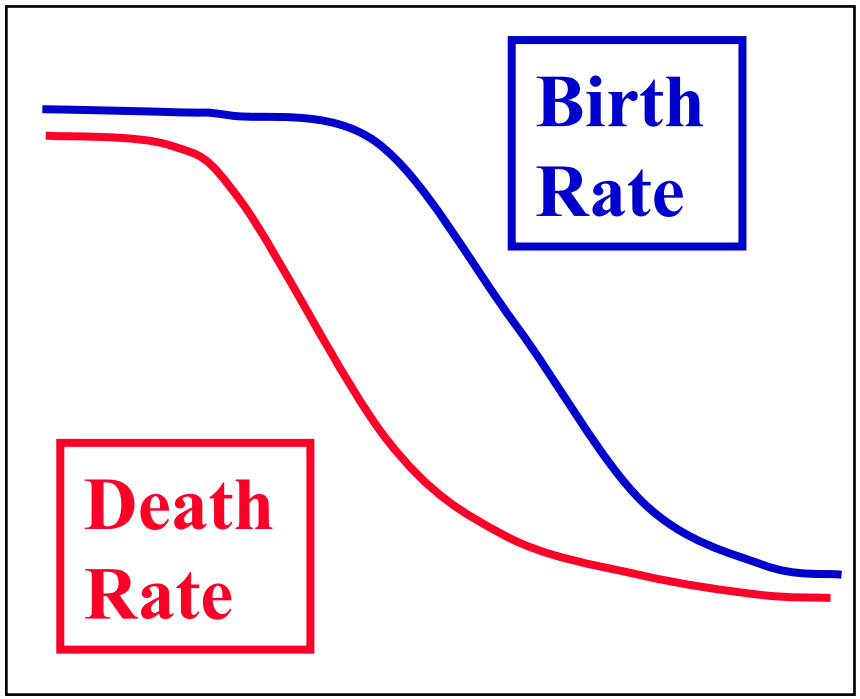
(Additional 2.5B are expected here)

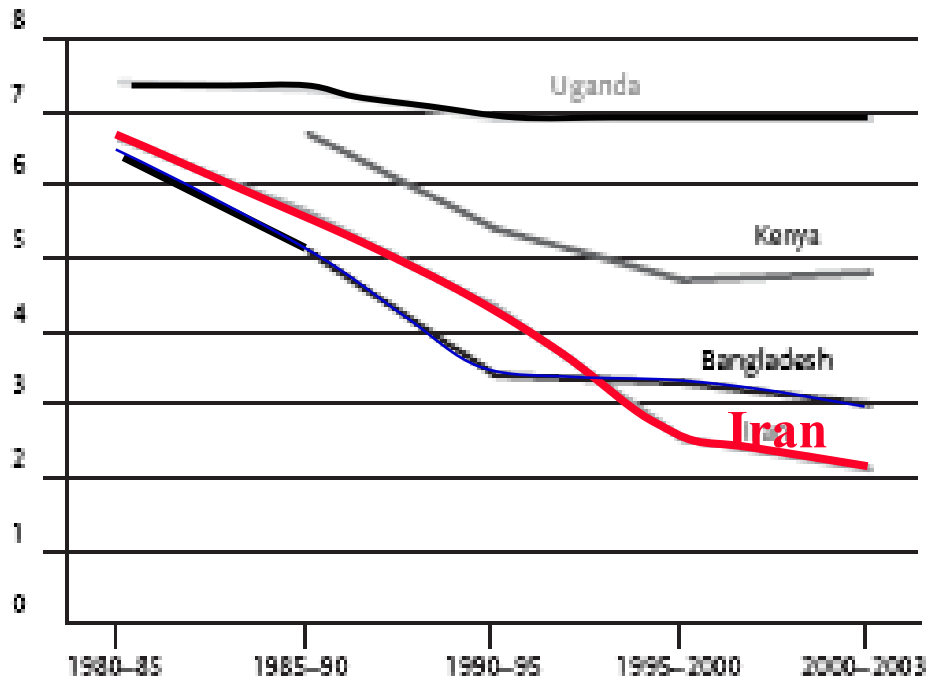
Population bulge | Changes in fertility

Access to health care (vaccines, antibiotics,…)

Lifetime births per woman:

Access to reproductive health



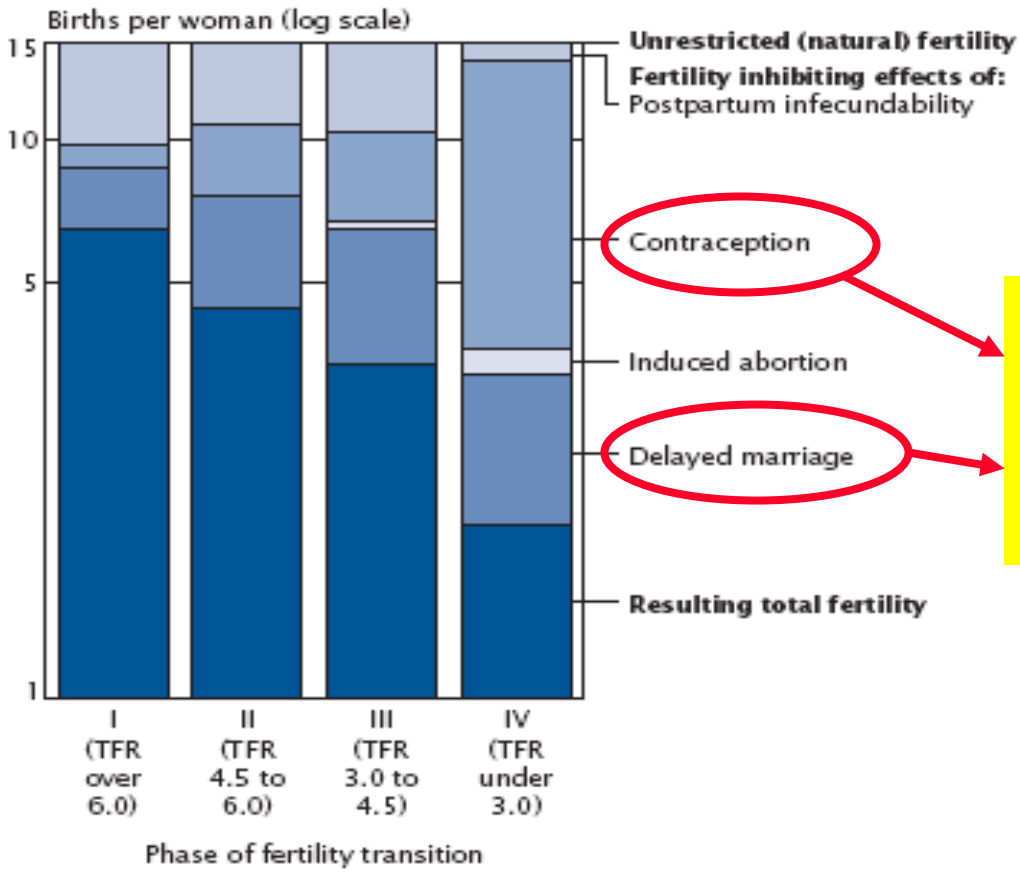


Sources: Demographic and Health Surveys and United Nations Population Division.

Changes in fertility: planned families

Conceptual Model of the Changing Contribution of Contraception and Other Proximate Determinants to Fertility Decline

The relative importance of factors determining fertility level varies with phase of fertility transition.



Source: Bongaarts (1982).

Importance of women's rights & Education

Goal: Reproductive Health & Planed Family

Provide every man and women with easy and free access to modern family planning and disease prevention methods (pill, IUD, condom, vaccines against STIs, …)

A Global Fund for free IUDs, pills, condoms: ~$10B/year

Population Challenge

	Social	economic	technical	scientific	political
Aging	✓	✓	✓	✓	✓
Growth	✓	✓			✓

2) Global Public Health

Why are

HIV/AIDS, Tuberculosis, SARS, Avian flu, …

NOT sufficient calls to action?

A stitch in time saves nine

It is very expensive, if at all, to fix the burden of

- **Vaccine preventable diseases**
- **Infectious diseases**
- **Diseases caused by pollution (e.g. lead)**
- **Alcohol, tobacco, narcotics addiction**
- **Malnutrition**

Every child has the right to basic health care and adequate nutrition

Living Dangerously

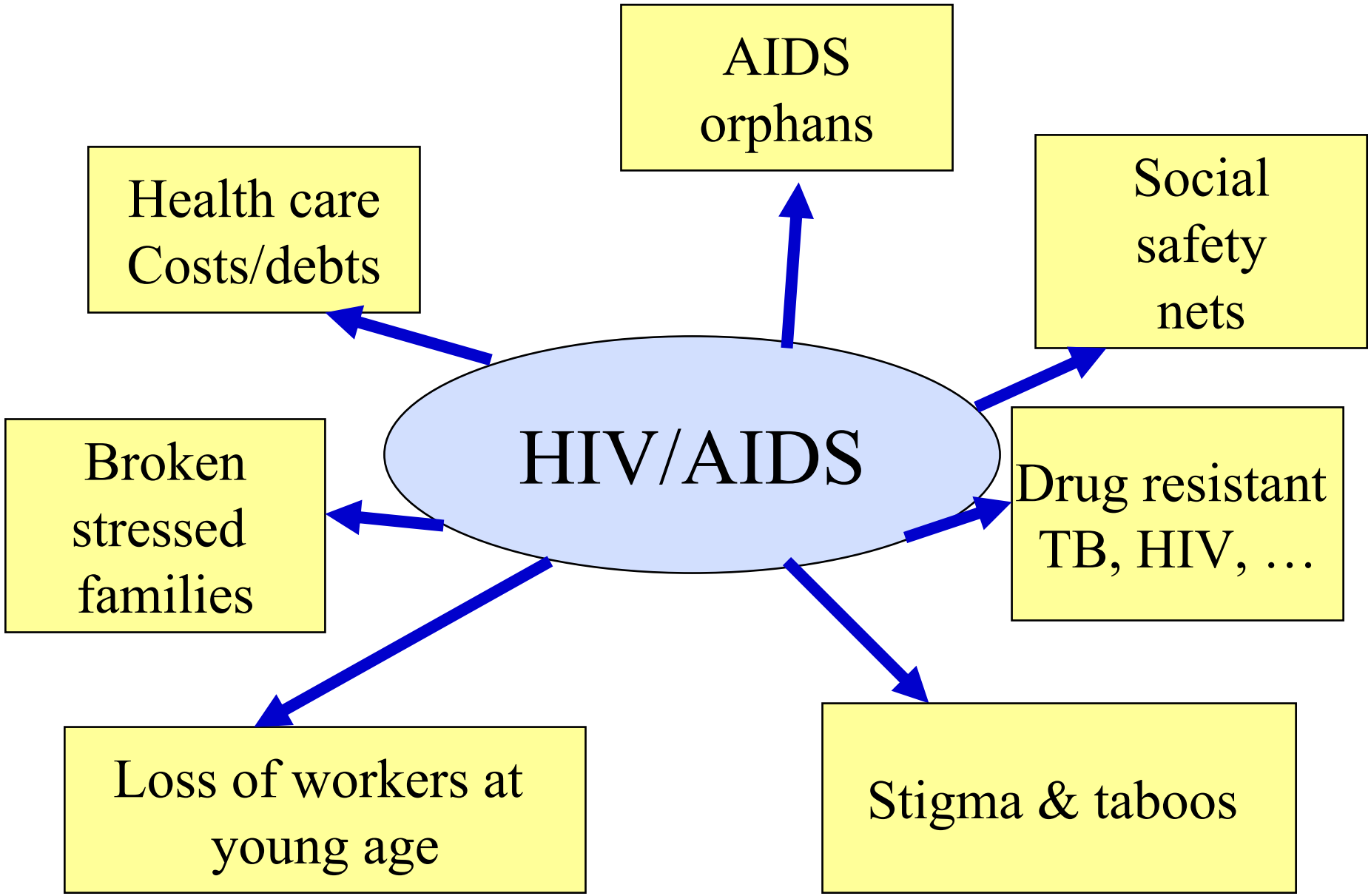
The world is living dangerously, either because it has little choice or because it is making wrong choices. On the one side are the millions who are dangerously short of the food, water and security they need to live. On the other side are the millions who suffer because they use too much [or are too indulgent]. All of them face high risks of ill-health.

Address by Gro Harlem Brundtland to the 55th World Health Assembly.

http://www.who.int/director-general/speeches/2002/english/20020513_addresstothe55WHA.html.

HIV/AIDS is exceptional

- Long asymptomatic infectious period (~10 years)
- Almost always fatal
- No cure or vaccine
- Sex and IV drug use – major transmission routes
- Stigma keeps risky sex and drug use underground
- Young adults most vulnerable
- Kills the most productive; leaving orphans
- Poor marginalized populations most vulnerable


AIDS orphans
Health care Costs/debts
Social safety nets
HIV/AIDS
Broken stressed families
Drug resistant TB, HIV, …
Loss of workers at young age
Stigma & taboos

A global jackpot fund for essential medicines and vaccines

Enhance the public private partnership for both crisis management and prevention of communicable and lifestyle diseases globally

Healthcare and nutrition

	Social	economic	technical	scientific	political
Vaccines	✓	✓	✓	✓	✓
Basic medicines	✓	✓			✓
Hygiene	✓	✓			✓
Nutrition	✓	✓			✓
Awareness	✓	✓			✓

3) Cheap clean energy for all

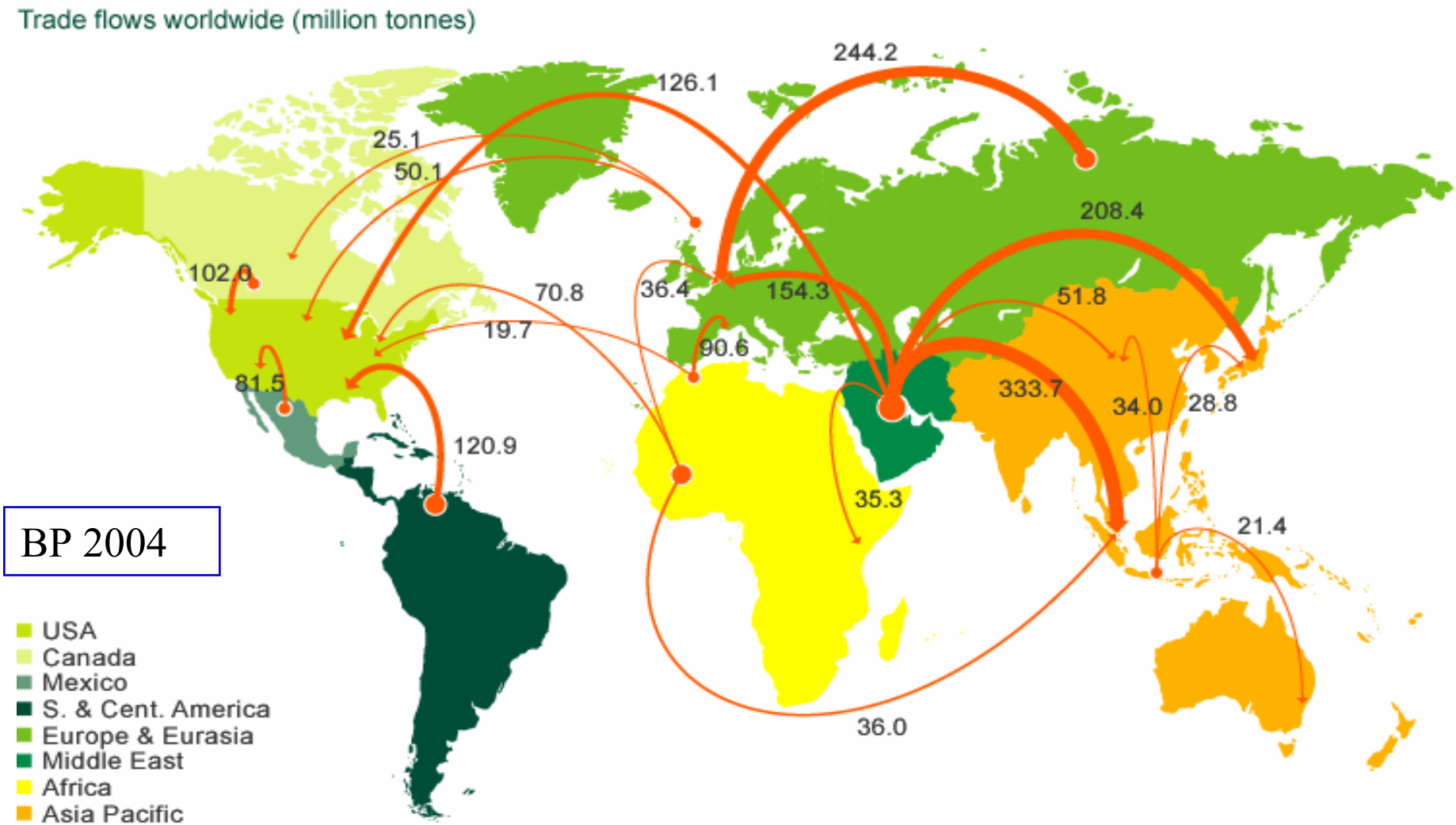
Essential for

- **Job creation**
- **Education**
- **Health care**
- **Mobility**
- **Environment and water management**

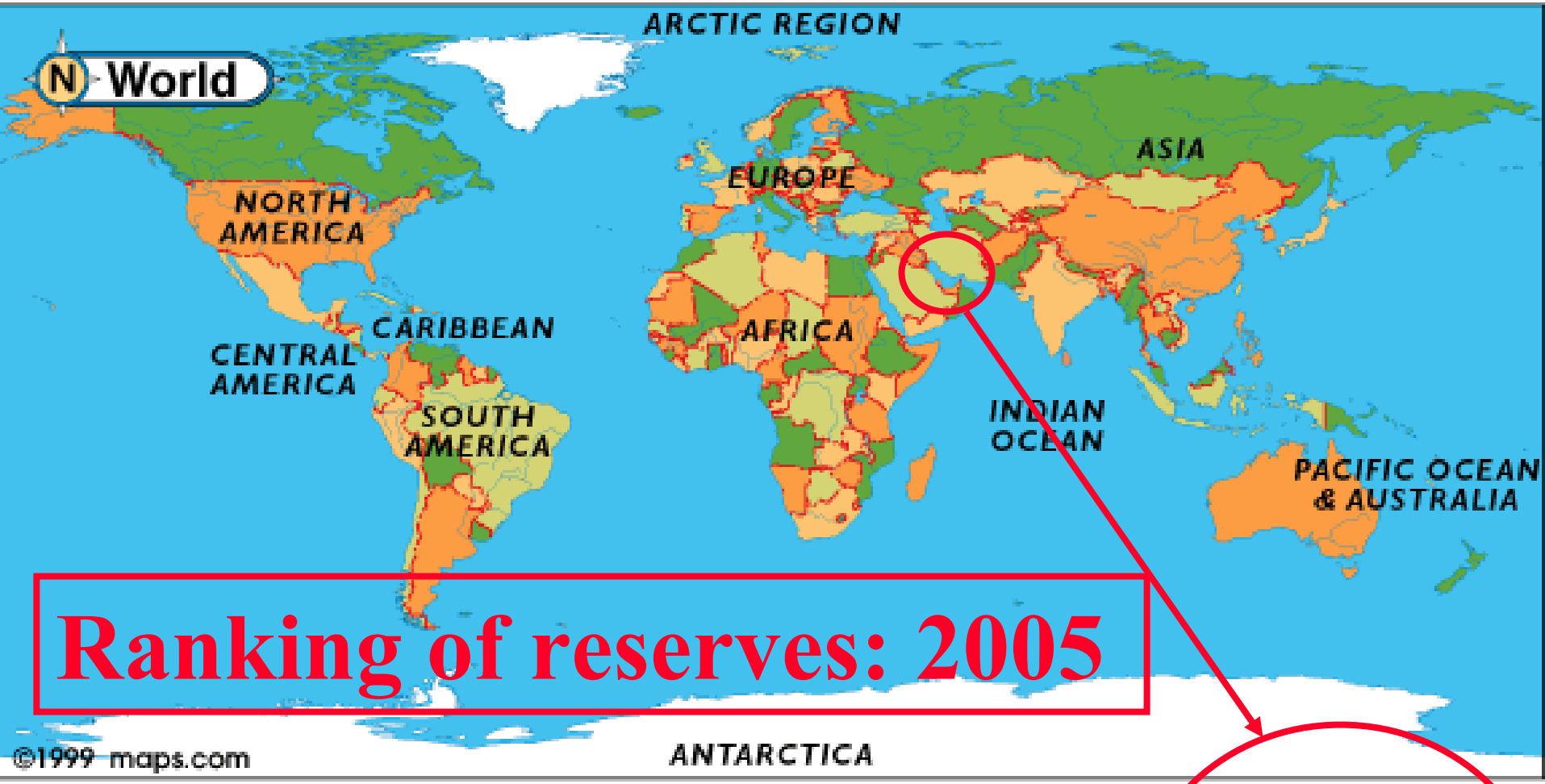
Each day every American uses

Source: Greg Swift

Oil: High density & easy to ship & store



The issues are demand ≥ production, geopolitics, strife



Ranking of reserves: 2005

USA 12,6,1

China 11,-,3

EU -, -, 4

Russia 8,1,2

India -, -, 5

AT -, -, -

Persian Gulf

OIL 1,2,3 4,5

GAS 2,3,4, 5,10

No Coal

Fast forward to 2020

USA ?,-,1

China -,-,3

EU -, -, 4

Russia ?,1,2

India -, -, 5

AT -, -, -

? → EOR

Persian Gulf

OIL 1,2,3 4,5

GAS 2,3,4, 5,9

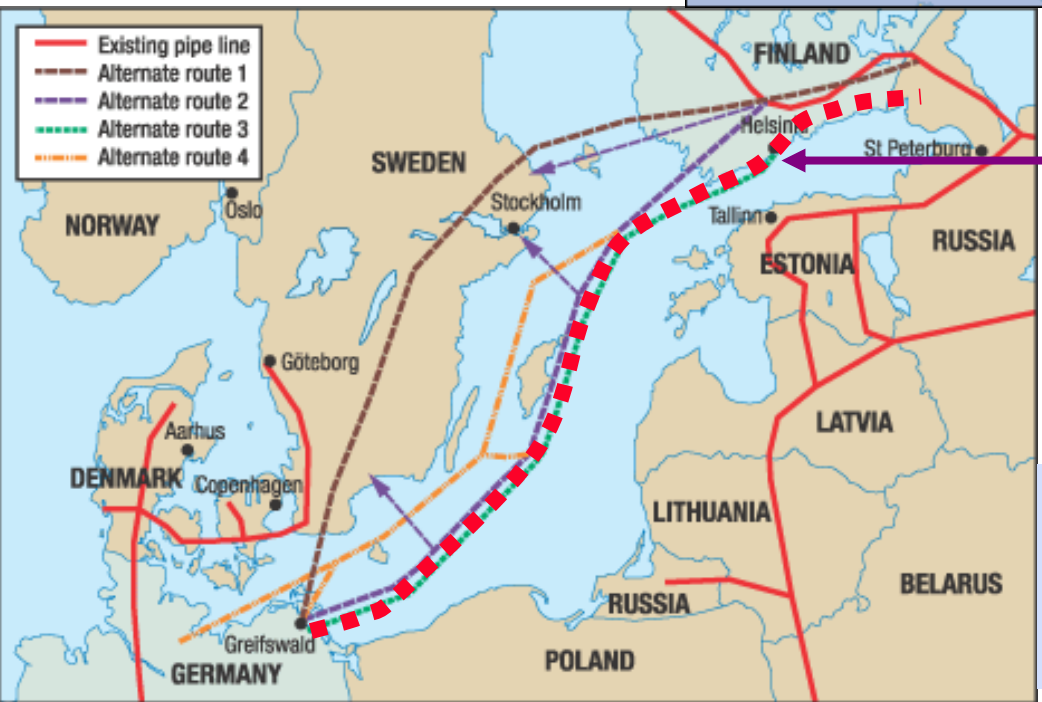
No Coal

Middle East and Russia control conventional natural gas and oil

PHILIPPE REKACEWICZ

She who owns the pipe lines gets the oil & gas!

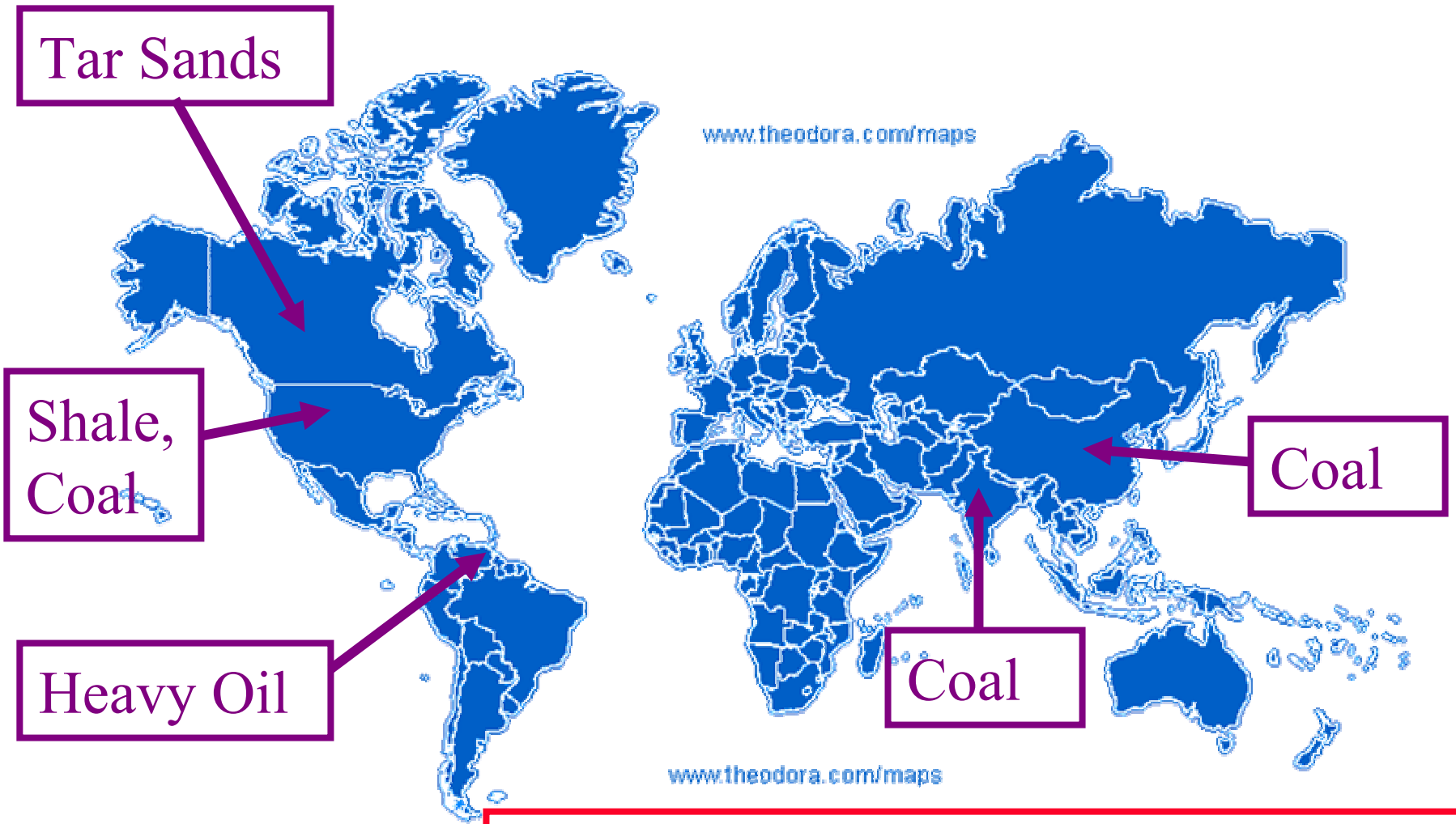
Which countries will get Russian natural gas in 10 years time?



New pipeline from Russia to Germany bypasses Ukraine and Eastern Europe

Natural destination is Europe & Asia

Unconventionals: Large reserves



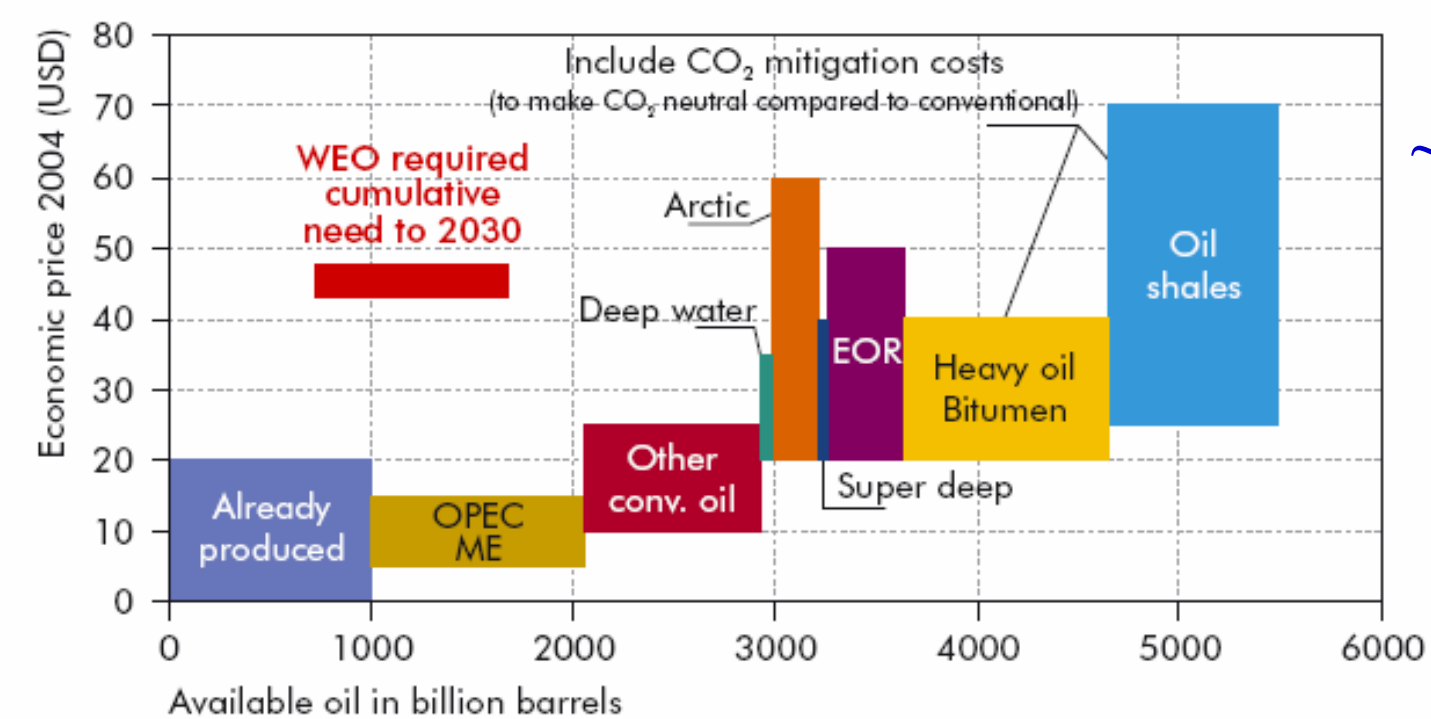
Problem is pollution and CO_2

Next 100 years burning of fossil fuels

	Av. (current)	Tera Tons C
• OIL:	100 (85) Mbo/day	→ **0.5**
• Gas:	1.5 (3/4) Tcf/day	→ **0.7**
• Coal:	30 (14) M tons/day	→ **1**

½ accumulates in the atmosphere & **2.1 GtC = 1 ppm**

~900ppm

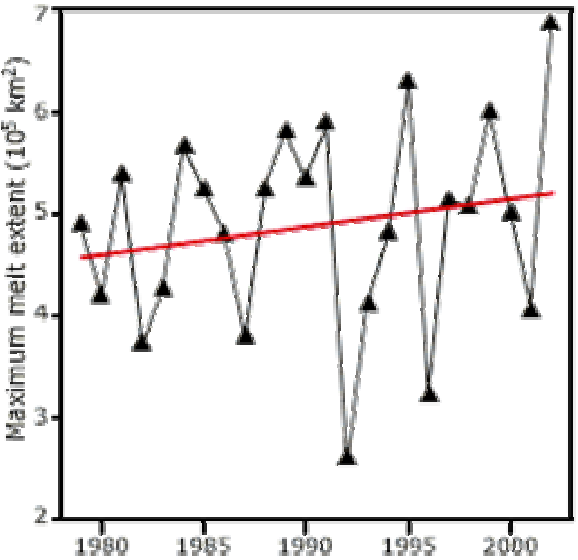


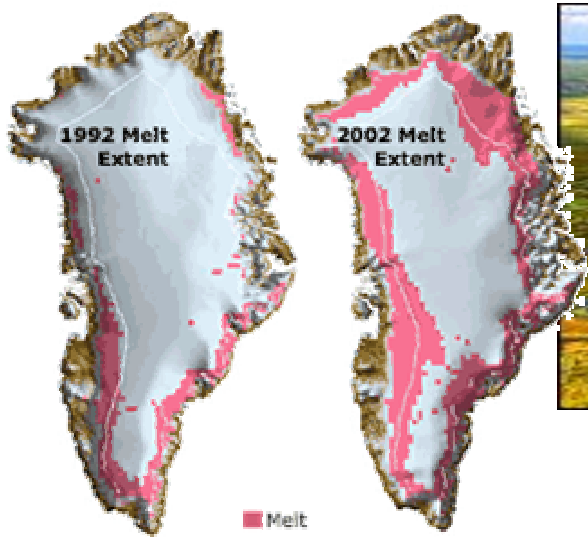
3.7 T barrels

Fossil fuels and Environment

In the 20th century we started to act on pollution (NOx, SOx, acid rain, soot, mercury?, ...) but <u>not</u> Green House Gasses like CO_2 and the associated global climate change

CO_2 is a greenhouse gas. *It forms a blanket around the earth that causes warming*





http://earthobservatory.nasa.gov/Study/vanishing/

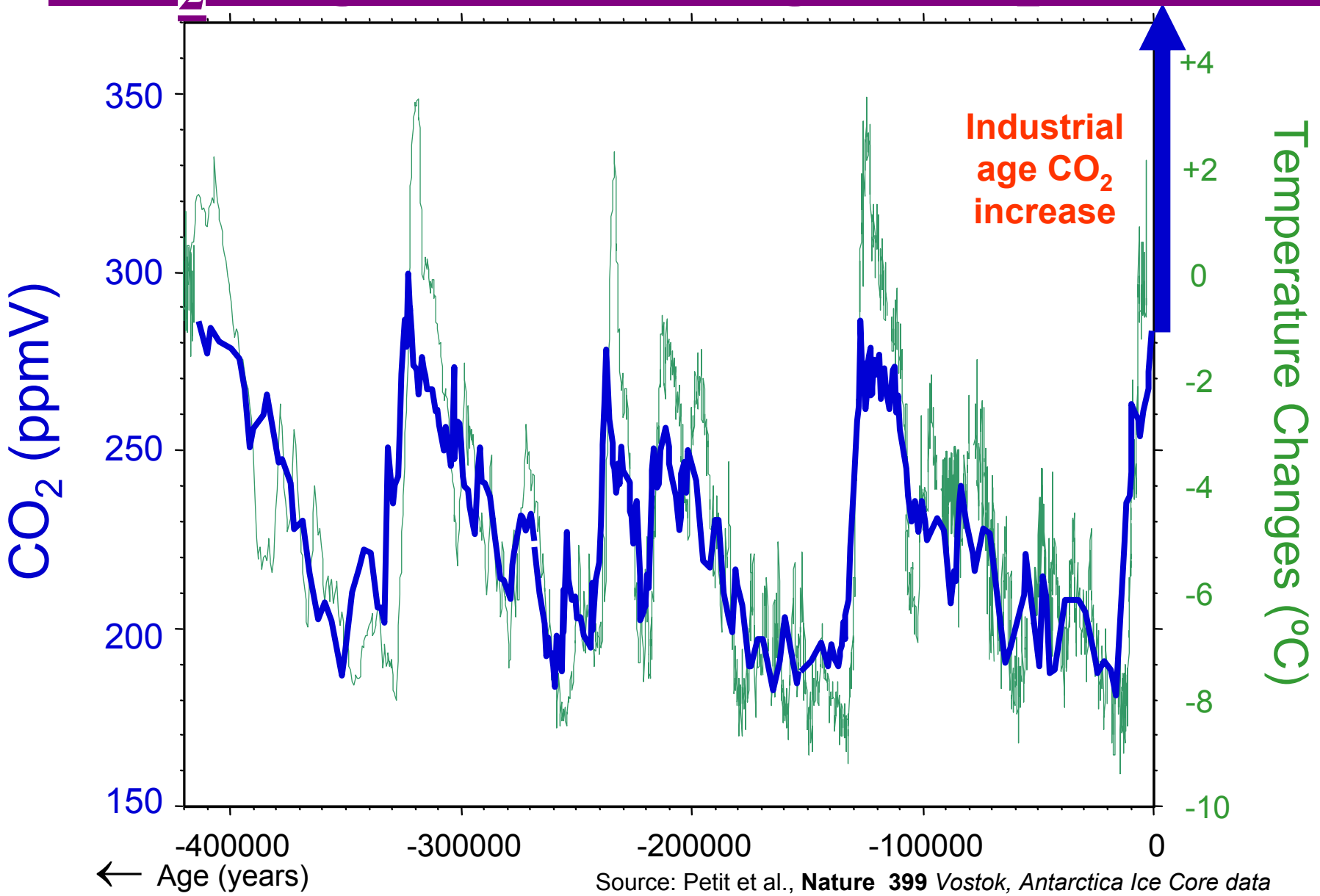
Melting of permafrost

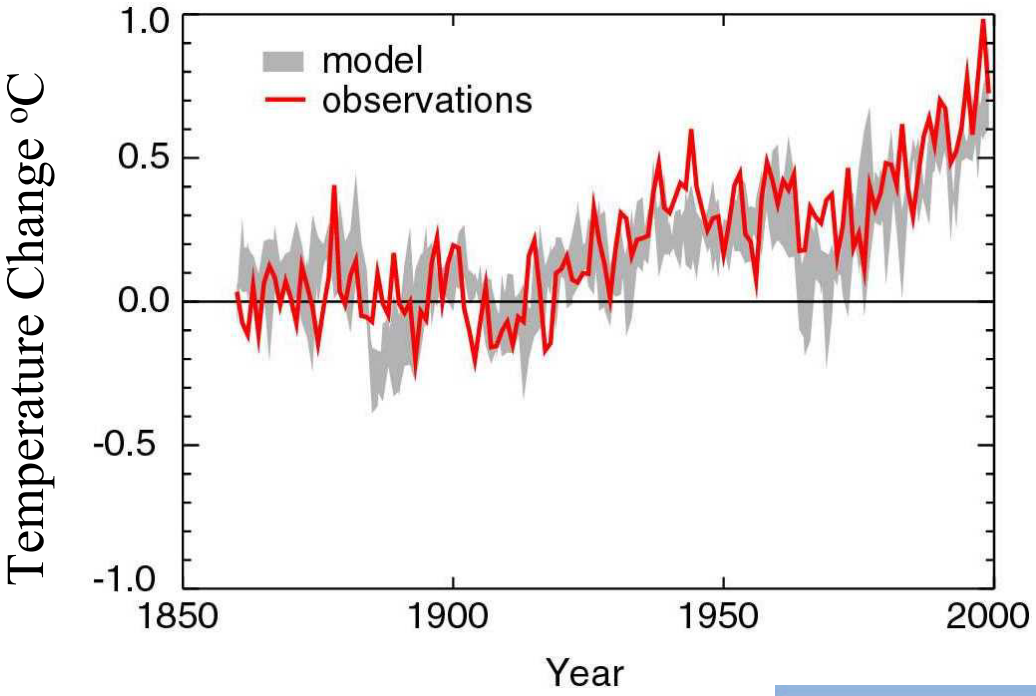
Melting of glaciers in Greenland and around the world. Is it global warming?

Intense storms

Sequestration of CO_2: First capture CO_2 and then store it

CO_2 & global average temperature

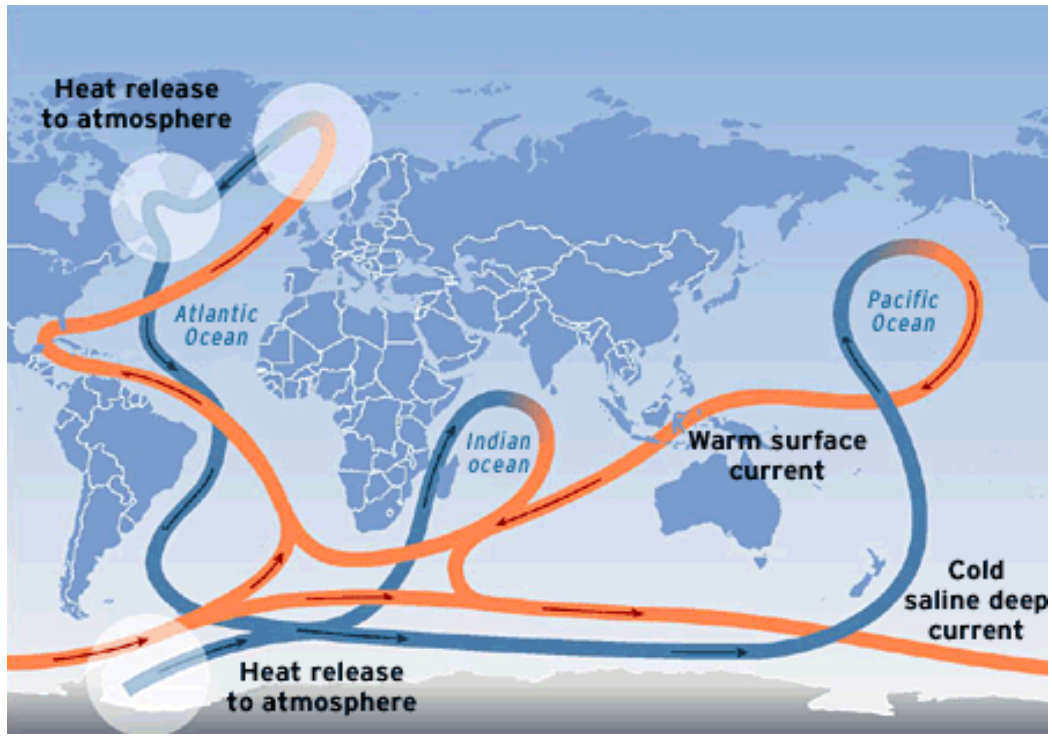




Increasing evidence for rise in average temperature due to fossil-fuel burning

Possibility of catastrophic change:

Shutdown of the thermohaline in 10s of years



Climate change is the largest, costliest, most dangerous, uncontrolled experiment ever done by mankind

Industrialized countries must lead

- **Develop and commercialize cheap clean energy**
  - **Hopefully before cheap oil (2010?) and gas (2035?) production < demand**

- **Large scope for cost-effective energy efficiency in homes, buildings, manufacture and transport**

A tremendous economic opportunity:
A $48B/day market at 5c/kwh

Cannot have cheap clean energy for all without some key S&T at tera scale

- Separation/capture of CO_2 from mixed gas streams
- Secure and effective long-term storage of CO_2.
  - Geologic, mineralization, …

CCS

- Hydrogen from water without using fossil energy:
  - Electrolysis of water (inexpensive and efficient electrodes)
  - Photochemical and/or thermo-chemical splitting of water
- Photovoltaic cells ($\rightarrow$ \$1/peak watt installed)
  - nano and/or bio PV materials integrated into systems

Solar

- Advanced nuclear fuel cycle and reactors
  - separation of SNF, transmutation, fuel reassembly, waste
- Fusion?

Nuc

4) Managing the environment and water resources

Immense Environmental Challenges

- Green house gases and global climate change
- Accelerating loss of habitats and species
- Ecosystems under increasing stress
- Deforestation
- Soil erosion and degradation
- Alien invasive species
- Food chains undergoing drastic changes (meat use↑)

- Pollution of rivers, lakes, coastal areas
- Eutrophication (fertilizers reaching water bodies)
- **Depletion/pollution of ground water**

Environment and Water Challenge

	Social	economic	technical	scientific	political
Env.	✓	✓	✓	✓	✓
Water	✓	✓	✓		✓

5) Nurturing and Educating children for 22 or more years

It takes ~100 watts to keep a person alive and in servitude. It is much harder to provide every kid a nurturing environment and ~4000 watts of power that would allow them to develop skills to control their destiny in the 21st century

Life in the 21st Century

- Pace of change is rapid and increasing
- Many more options and stresses
- Expected to make high consequence decisions often and at younger age
- Stress management is increasingly important
- Premium on
  - Higher education
  - Technical skills
  - Emotional health
  - People skills
  - Healthy lifestyles

Kids need a loving, caring, healthy environment to grow up in and good higher education

Education: a public-private partnership

- Stable funding
- High quality teachers and researchers
- Motivated students
- Aligned priorities of parents and society
- Kids growing up in healthy environment

- Education increasingly becoming a business
- Well funded private institutions set standards
- Shortage of good teachers (math and science)

Kids that fall off the table

- More prone to risky behaviors
- More likely to have unhealthy lifestyles
- Fewer career options
- Less able to make sound long term financial decisions or investments
- Less able to provide a nurturing environment to their children or help with higher learning

Do they compound the

- **Health care, environmental problems?**
- **Are they good future providers and stewards?**

In the absence of healthy leisure time activities people gravitate towards

- Shallow television
- Gambling
- Alcohol and drugs
- Risky sex → HIV/AIDS

Need education and meaningful jobs

Disillusioned and without hope

- Crime
- Violence
- Gangs
- Militias
- Terrorists

Social and political instability

Poverty: a compounding factor

- A child without nourishment falls sick & cannot focus
- A child without health care is handicapped
- A child is defenseless in unhealthy environments
- A child without education faces a life of servitude
- A child without “love” faces emotional handicaps
- A child without hope and anchors is an easy prey
- Without energy a family remains in darkness

Population growth is in the poor

Keeping kids on the table: highest priority long term investment

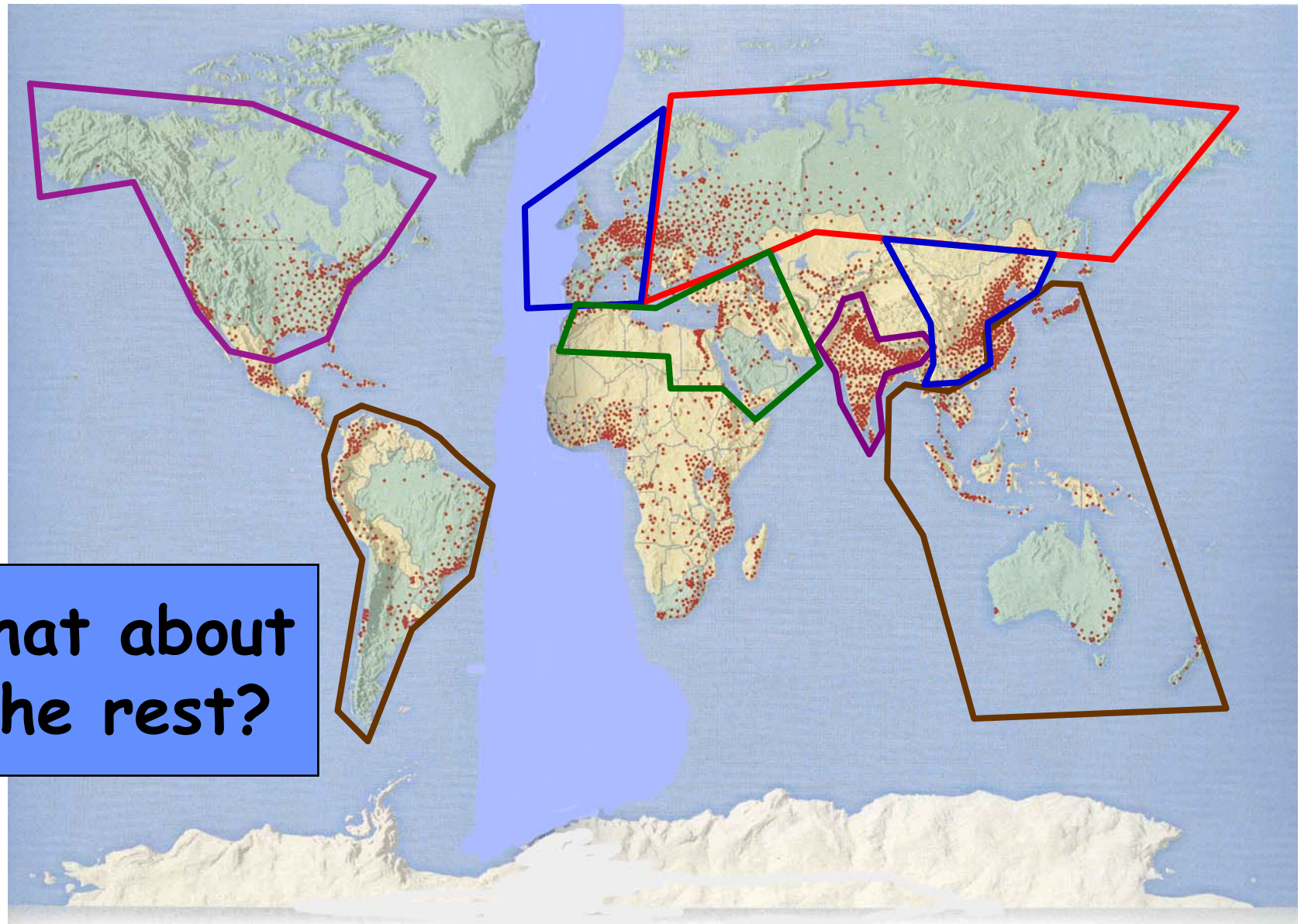
	Social	economic	political	parents	schools
Raising strong kids = our future = security	✓	✓	✓	✓	✓

Conclusion

Why we must act with urgency?

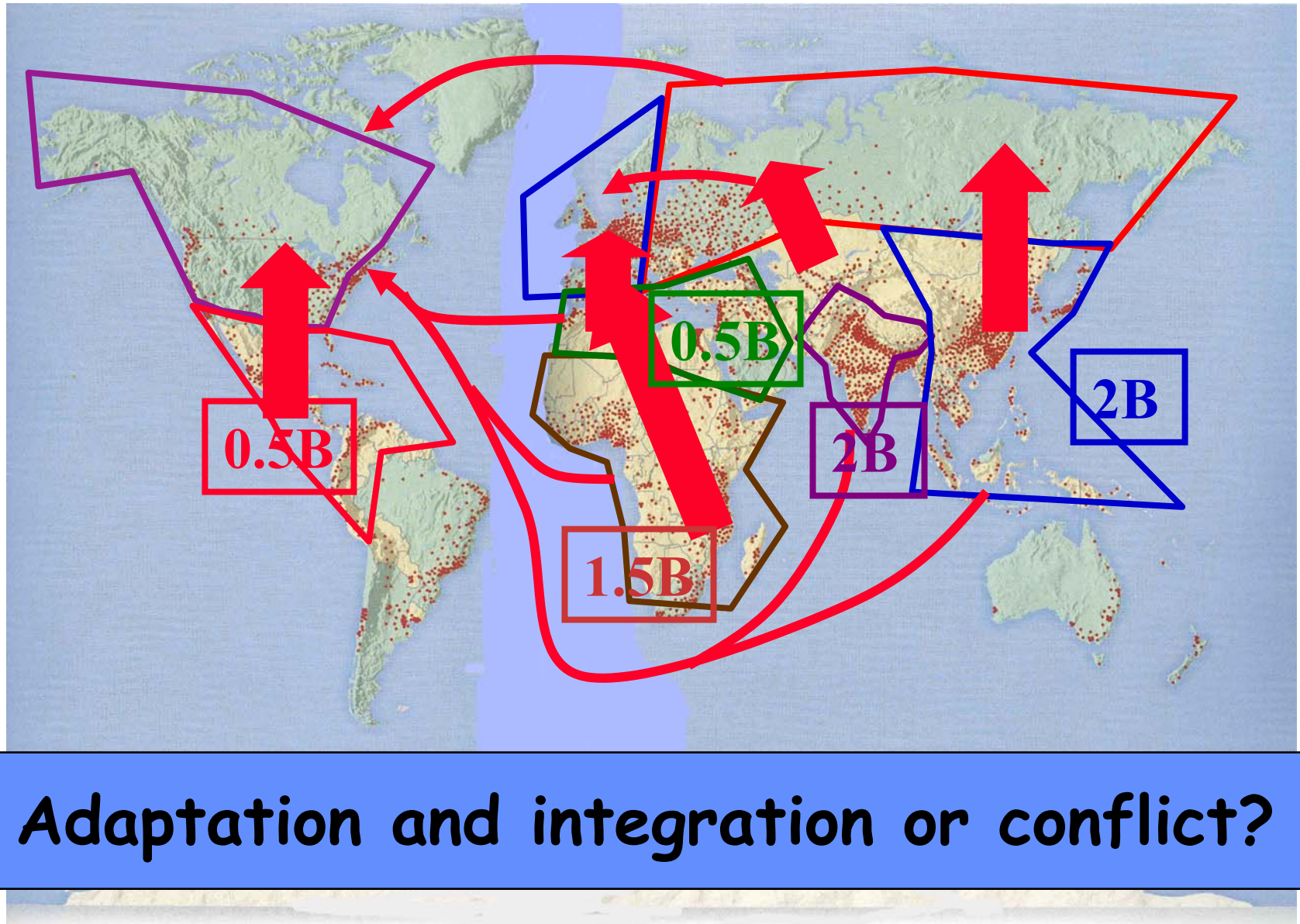
Scenario Under Business-as-Usual

Eight Economic Zones: each of about 400M "global" people



What about the rest?

Pressure of migration 6.5B ➔ 1B



Adaptation and integration or conflict?

Migration and Reinvestment: Examples of accelerated change

- **Migration created a global Indian community**
  - **Similarly:** China, Taiwan, Ireland, Israel, Korea, Singapore
- **Migrant community has skills, entrepreneurship, capital, ties and genuine empathy**
- **Helped create IT revolution in US & India**
- **Many are keen to help and invest in India**
- **Can engage meaningfully in poverty reduction, health care, education and development**

Prerequisites: **Stability and educated workers at home**

Caution: **Don't over fish developing pools**

Impediments to development: Sharks and Barracudas that come in many guises

- Despotic, corrupt governments
- Exploitative business
- National and transnational criminals
- Fanatics and terrorists

Failed states are a global challenge

Rocking a leaking boat

- Impact of catastrophic events?
- Impact of conflicts and wars?
- Global climate change?
- Population growth, demographics, urbanization, migration, refugees
  - Especially if developing countries fail

- Resilience/adaptability of systems under stress?
- Need nation building not failed states

The more we ignore the needs of the poor and the marginalized, the more we empower the despots, the sharks and the barracudas!

Questions?

- **Promote a race towards first world consumption or help develop access to basic rights for all?**
- **Globalized world –**
  - **Can/will free/competitive markets create stability in supply and demand?**
  - **Can we come to an agreement on equity?**
  - **Should environmental remediation costs be factored into product costs?**
- **Can competition in a resource limited world foster co-operation?**
  - **Global identity (transcending family, communal, religious and national interests)**

A challenge to modelers

We are starting to understand the networks and strengths of the interconnections at the macro level.

We need to better understand the rules and dynamics at the micro (people) level

Must develop tools to bridge the scales and anticipate collateral/ripple effects

Hope versus Hunger

We understand threats to people &nature
We have tools to deal with them
Will we grow the will and act in time?