19ENV300/ Environmental science and sustainability (P/F)

Course plan

Period	Topic coverage	Quizzes/ examination	
Unit 1			
1	Introduction/overview of the global environment crisis	25M Quiz 1 30 mins duration *via* AUMS	
2	Biogeochemical cycles		
3	Climate change and related international conventions and treaties and regulations		
4	Ozone hole and related International conventions and treaties and regulations		
5	Overpopulation ,energy crisis – Water crisis – ground water hydrogeology – surface water resource		
	Quiz 1		
Unit 2			
6-7	Ecology, biodiversity loss related international conventions – treaties and regulations	25M Quiz 2 30 mins duration *via* AUMS	
8	Sewage, domestic and industrial and effluent treatment –		
9	Air pollution and related international and local conventions		
10	Land, thermal and noise pollution		
	Quiz 2		
Unit 3			
11	Solid waste management (municipal, medical, e-waste, nuclear, household hazardous wastes)		
12	environmental management – environmental accounting – green business – eco-labelling		
13	environmental impact assessment –Constitutional – legal and regulatory provisions		
14	Sustainable development.		
	End semester Examination	50M - Quiz 2 60 mins duration *via* AUMS	

Evaluation Pattern-19ENV300 (P/F Course)

Evaluation	Marks	Duration of test	Mode of Quiz/Examination
Quiz -1	25	30min	AUMS/MCQ
Quiz- 2	25	30min	AUMS/MCQ
End sem Exam	50	60min	AUMS/MCQ

19ENV300/ Environmental science and sustainability

Syllabus

Unit 1

Over view of the global environment crisis – Biogeochemical cycles – Climate change and related international conventions and treaties and regulations – Ozone hole and related International conventions and treaties and regulations – Overpopulation – energy crisis – Water crisis – ground water hydrogeology – surface water resource development.

Unit 2

Ecology, biodiversity loss and related international conventions – treaties and regulations – Deforestation and land degradation – food crisis – water pollution and related International and local conventions – treaties and regulations –Sewage domestic and industrial and effluent treatment – air pollution and related international and local conventions– treaties and regulations – Other pollution (land, thermal, noise).

Unit 3

Solid waste management (municipal, medical, e-waste, nuclear, household hazardous wastes) – environmental management – environmental accounting – green business – eco-labelling – environmental impact assessment –Constitutional – legal and regulatory provisions – sustainable development.

Text Book(s)

R. Rajagopalan,"Environmental Studies – From Crisis to Cure", Oxford University Press, 2005, ISBN 0-19-567393-X.

Reference(s)

1. G.T.Miller Jr., "Environmental Science", 11th Edition, Cenage Learning Pvt. Ltd., 2008.
2. Benny Joseph, "Environmental Studies", Tata McGraw-Hill Publishing com Ltd, 2008.

Unit - 2 Principles of Ecology

Principles of Ecology

- **Segments of the Environment**
    - Atmosphere, Lithosphere, Hydrosphere, Biosphere
- **Ecosystem: Biotic and Abiotic Factors**
- **Organization of the Ecosystem**
- **Types of Ecosystems**
- **Structure of the Ecosystem**
    - Ecological Pyramids
- **Functions of Ecosystems**
    - Productivity
        - Food Production

- Energy Flow
    - Food Chain and Food Web
- Nutrient Recycling
    - Biogeochemical Cycles - Water Cycle, C, N, P, S Cycles
- Development and Stabilization
    - Community Associations
    - Community Adaptations
    - Ecological Succession

- **Ecosystems Services**
- **Economical values of Ecosystem Services**
- **Threats to Ecosystems**

Ecology - *Ikos*—dwelling; *Logos*—study

Study of the inter-relationships among living beings and their interactions with the physical environment[ref].

Autoecology - study of an individual species including behavior, adaptation and interaction with environment[ref]

Synecology - study of communities and their interactions with the environment[ref]

The Physical and biological habitat surrounding us is the in Environment, it has a four segments[ref]

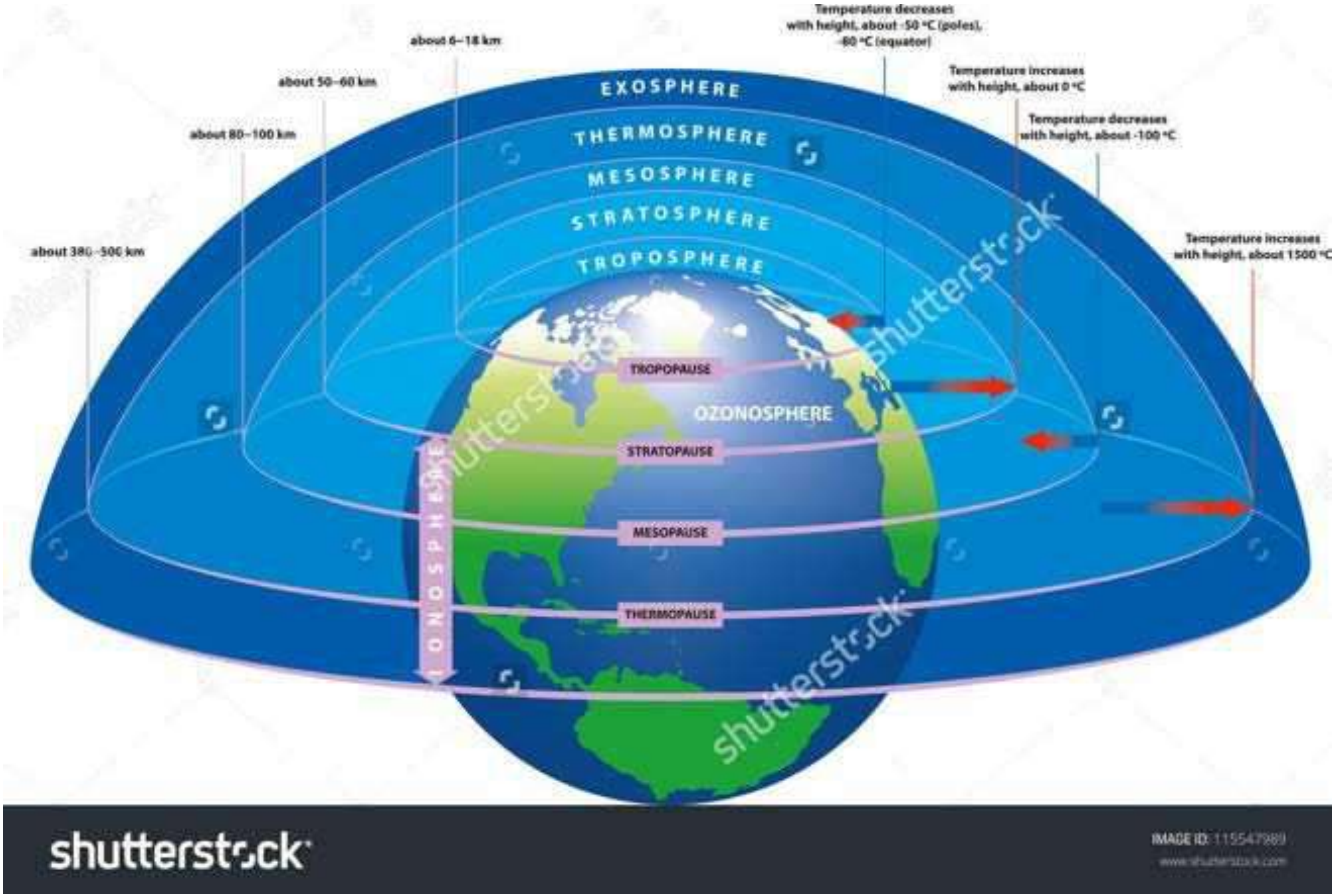
Atmosphere: small reservoir, efficient transporter.

Lithosphere: Earth’s Crust, rocks, minerals. Huge reservoir, less transport (conveyer), Pedosphere: soil

Hydrosphere: oceans and water, huge reservoir and transporter

Biosphere: small reservoir, moderate transporter; huge impact on the environment.

Atmosphere



http://view.ge/page/sience/15-atmosphere-of-earth?lang=english

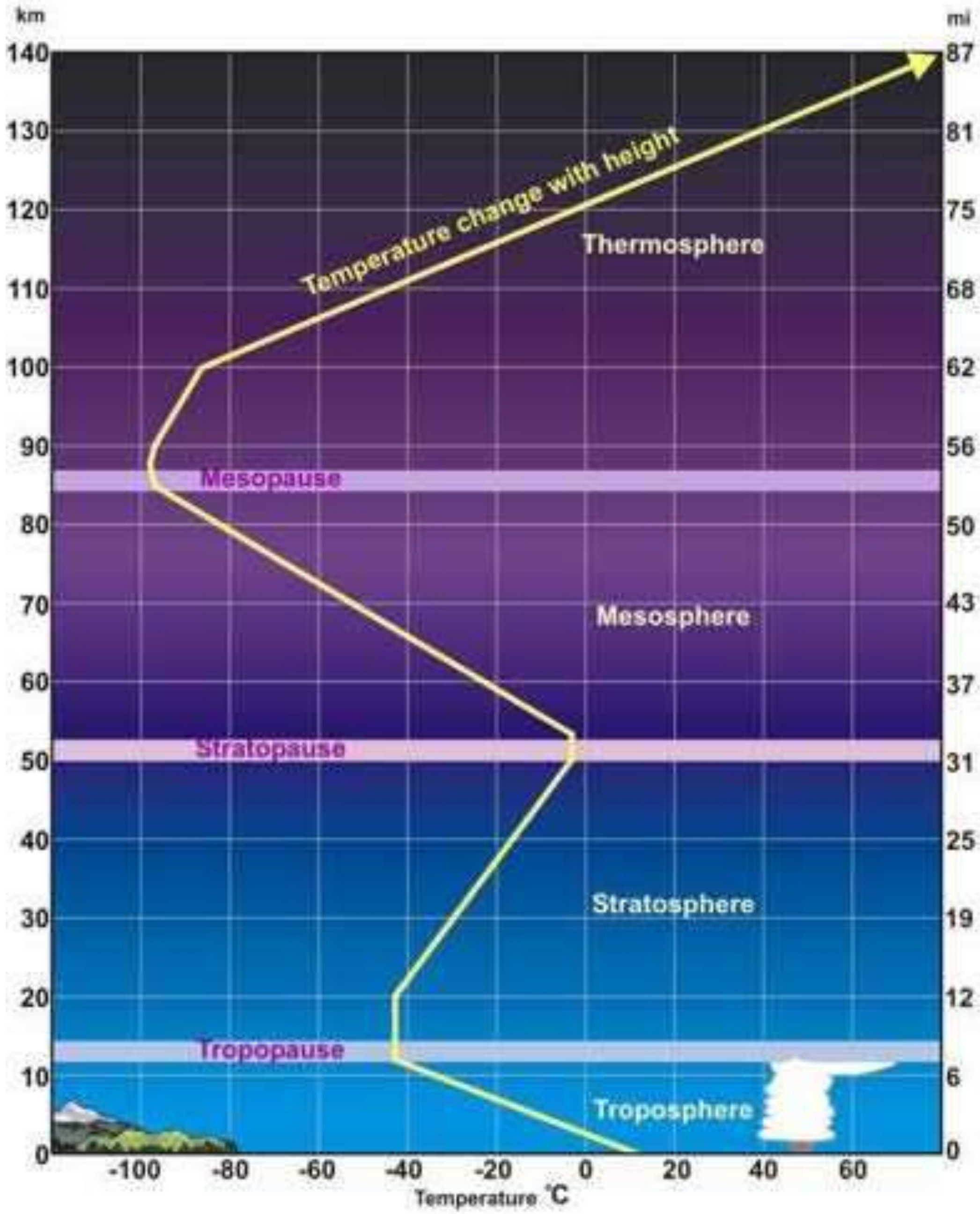
Exosphere: 500 – 1000 km up to 10,000 km,

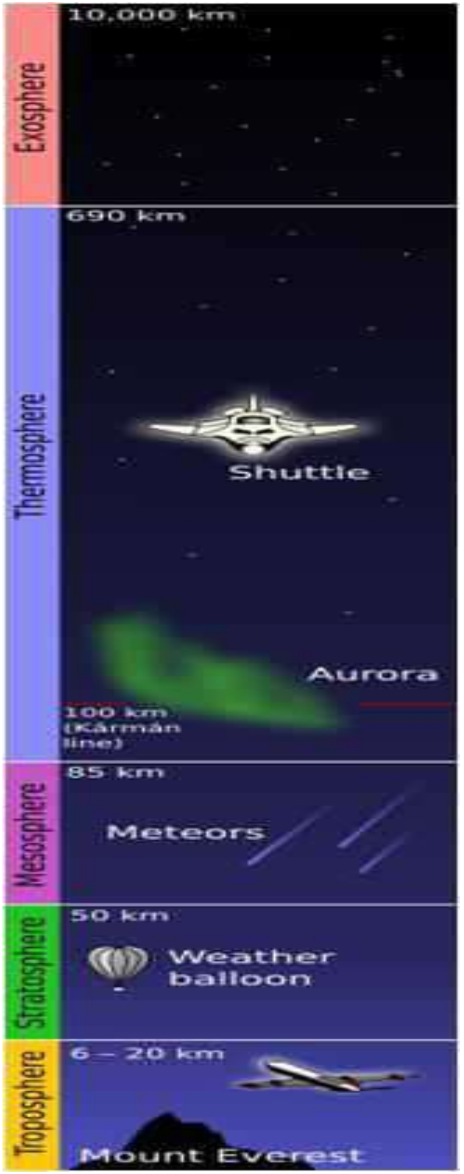
Thermosphere: from 80 – 85 km to 640+ km temperature increasing with height. **Ionosphere**: auroras, long distance radiowave propagation.

Mesosphere: 50 km to 80 to 85 km temperature decreasing with height. Meteors burn up when entering the atmosphere.

Stratosphere: 7 to 17 km range to about 50 km Temperature increases with height. Ozone—few ppm (Mainly 15 to 35 km)

Troposphere: Surface to between 7 km at the poles and 17 km at equator. Weather variations , vertical mixing





http://www.theozonehole.com/atmosphere.htm

Ecosystem

Ecosystem is a functional unit consisting of living and non-living components[ref].

Abiotic factors[ref]:

- Climatic: temperature, rainfall, snow, light levels, wind, humidity
- Edaphic (Soil) Factors: pH, mineral and organic matter, texture

Biotic Factors[ref]:

- Producers (Autotrophs): green plants; chlorophyll
- Consumers (Heterotrophs) pri., sec., ter. consumers
- Decomposers (Saprotrophs): Bacteria, fungi

Organization of the Ecosystem ref

Individual, Species, Organism: An individual living thing, genetically similar enough to breed and produce live, fertile offspring in nature ref

Population: All members of a individual that live in the same area at the same time ref

Biological Community: All populations living and interacting in an area ref

Ecosystem: A biological community and its physical environment ref

Biome: is a set of ecosystems sharing similar characteristics with their abiotic factors adapted to their environments ref

Biosphere: A biosphere is the sum of all the ecosystems established on planet Earth. It is the living (and decaying) component of the earth system ref

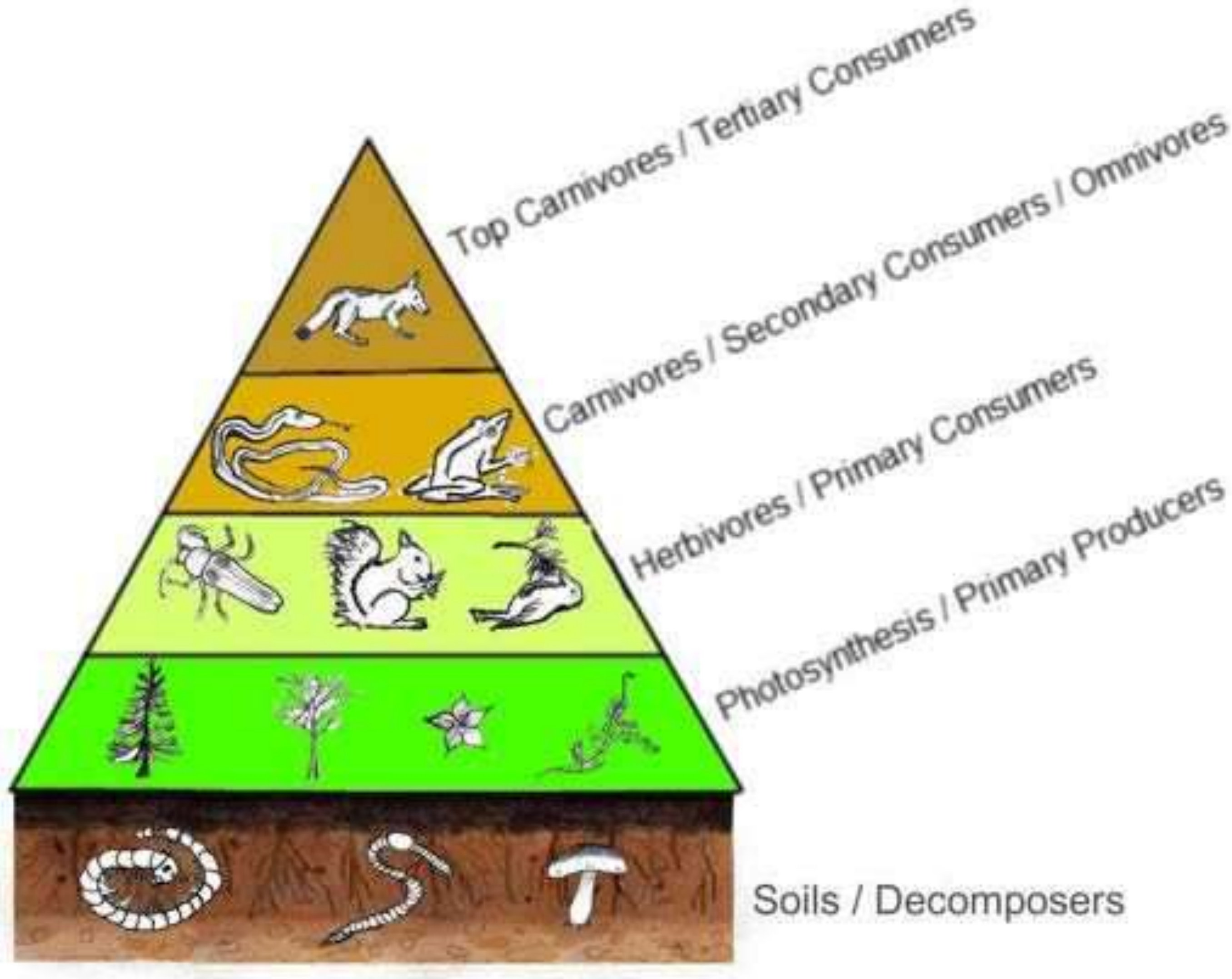
Types of Ecosystems ref

Natural, Artificial

Aquatic Ecosystem: An ecosystem which exists in a body of water is known as an aquatic ecosystem. Majorly two types, **Freshwater ecosystems** and **Marine ecosystems** ref

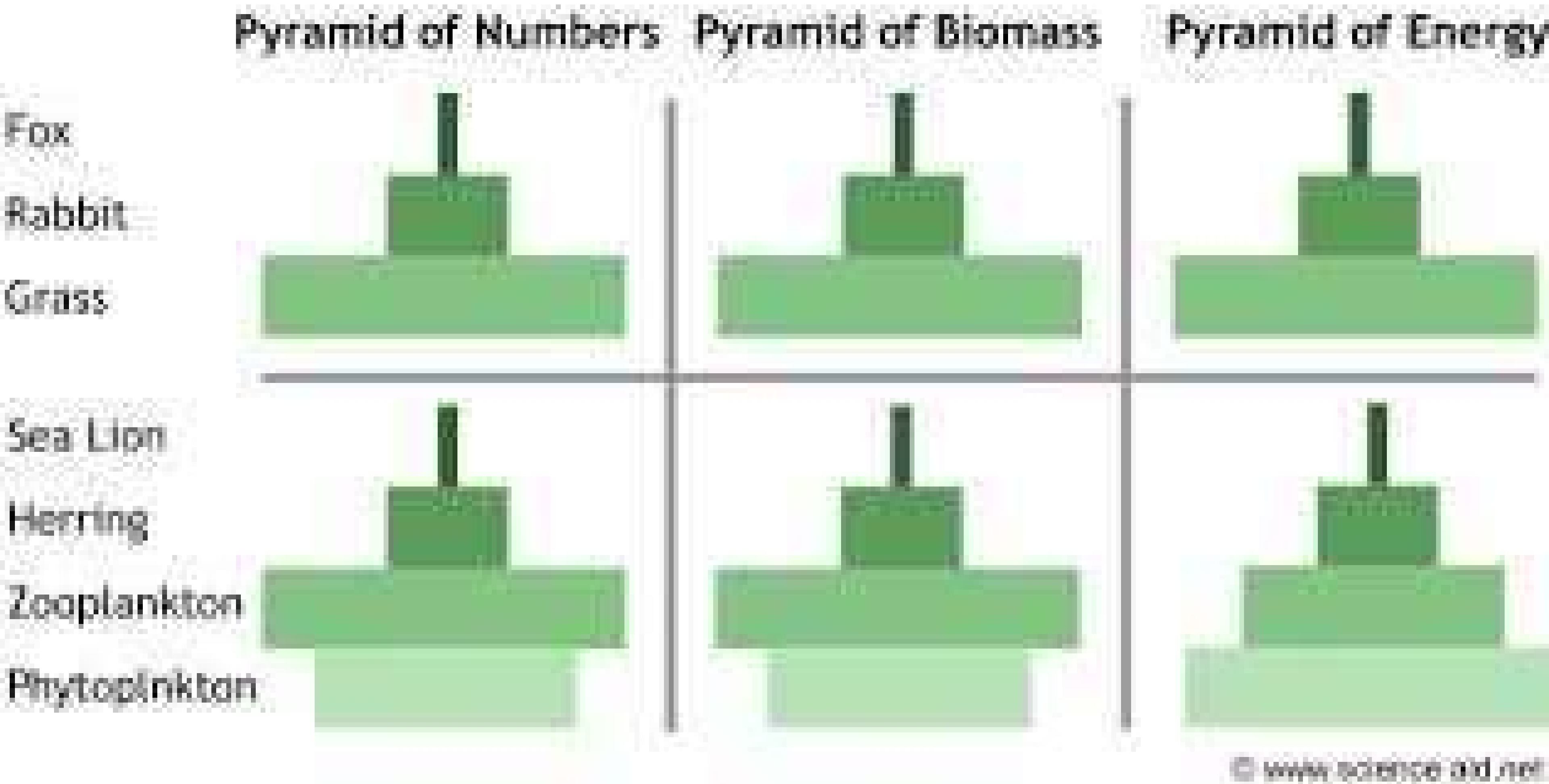
Terrestrial Ecosystem: The ecosystem which is found only on landforms is known as the terrestrial ecosystem. The main types of terrestrial ecosystems are **forest ecosystems, desert ecosystems, grassland ecosystems and mountain ecosystems.** ref

Structure of the Ecosystem - Ecological Pyramids or Trophic Pyramids



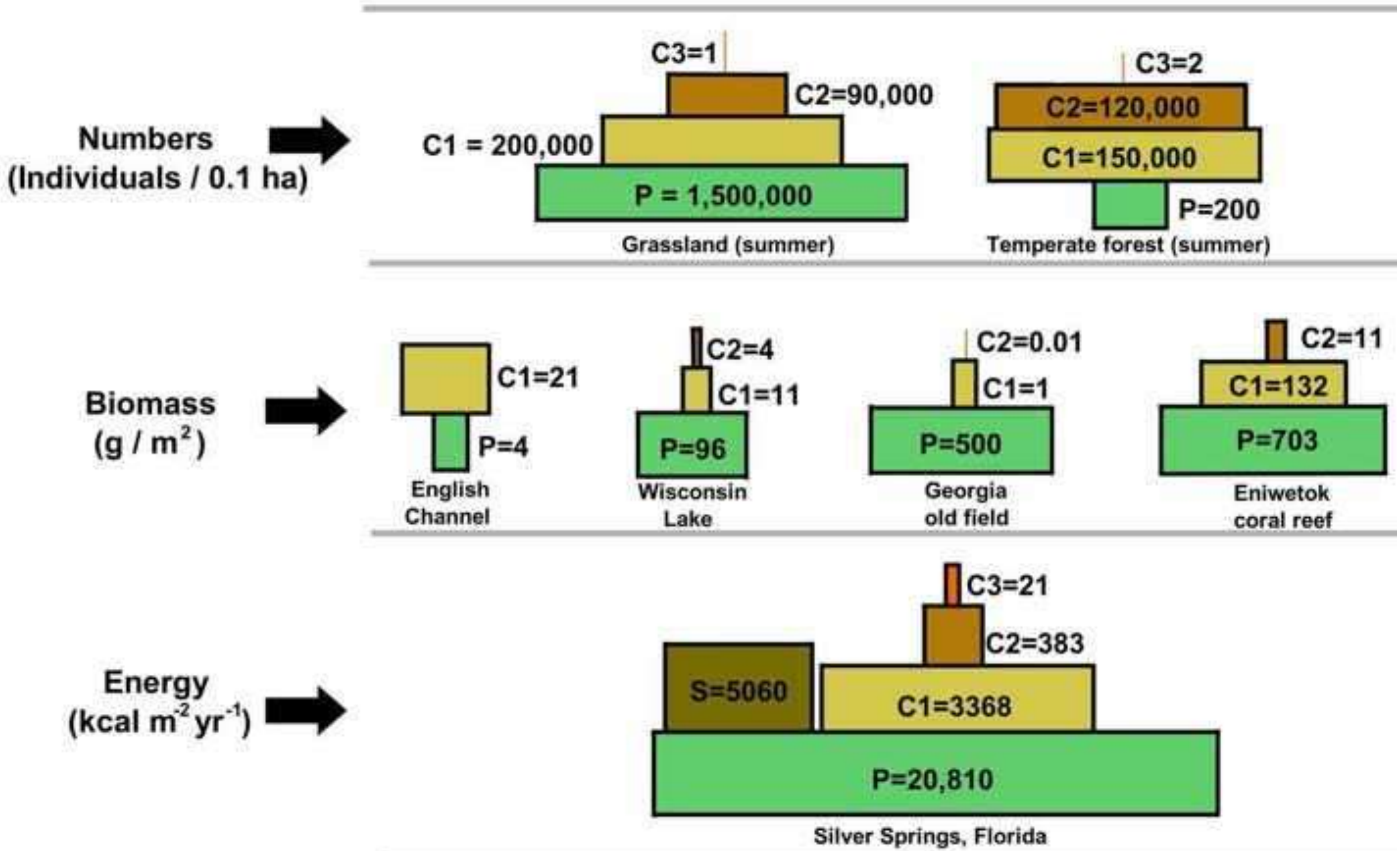
https://en.wikipedia.org/wiki/Food_web

Types of Ecological Pyramids or Trophic Pyramids: Terrestrial Vs Aquatic Ecosystem



http://scienceaid.co.uk/biology/ecology/food.html

Variations in Ecological Pyramid



https://en.wikipedia.org/wiki/Food_web

Ecosystem Functions[ref], [ref]

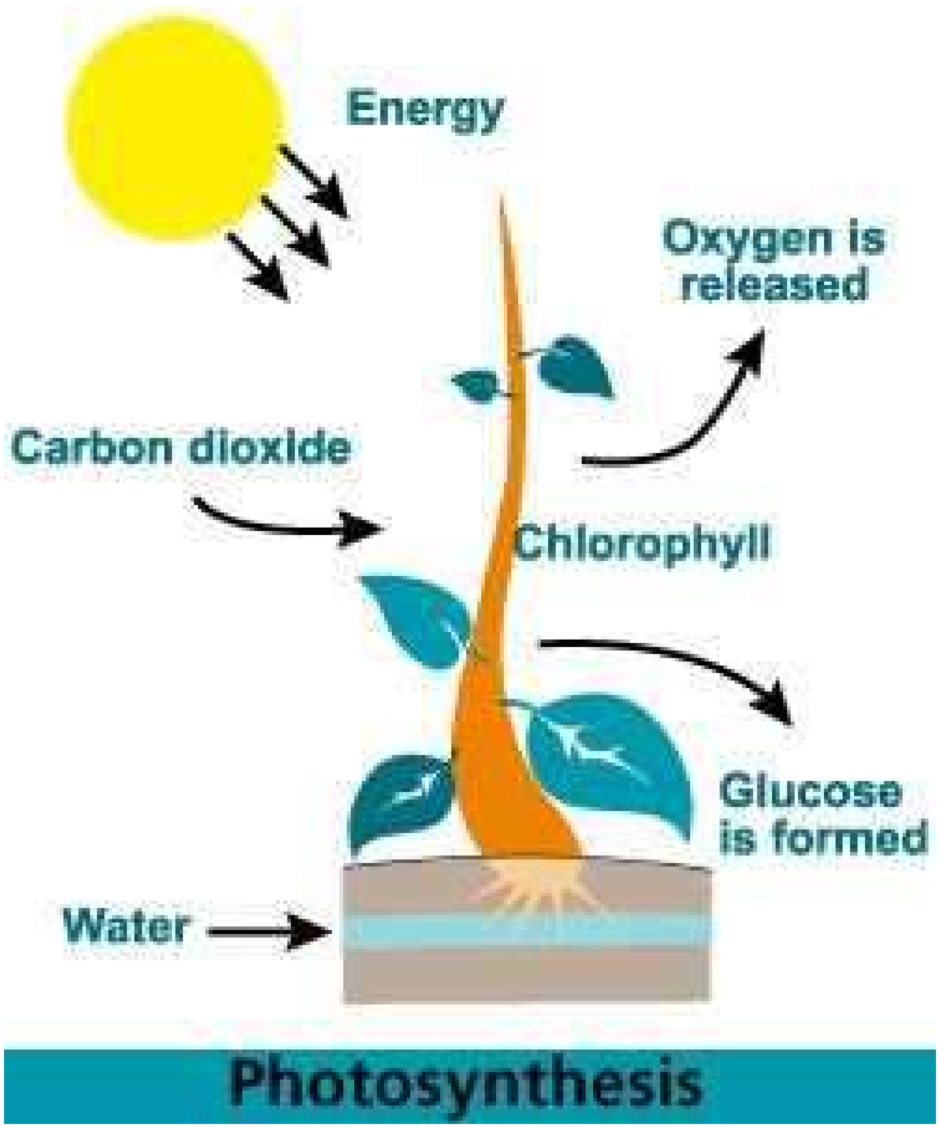
Productivity - Food Production

Energy Flow - Food Chain, Food Web

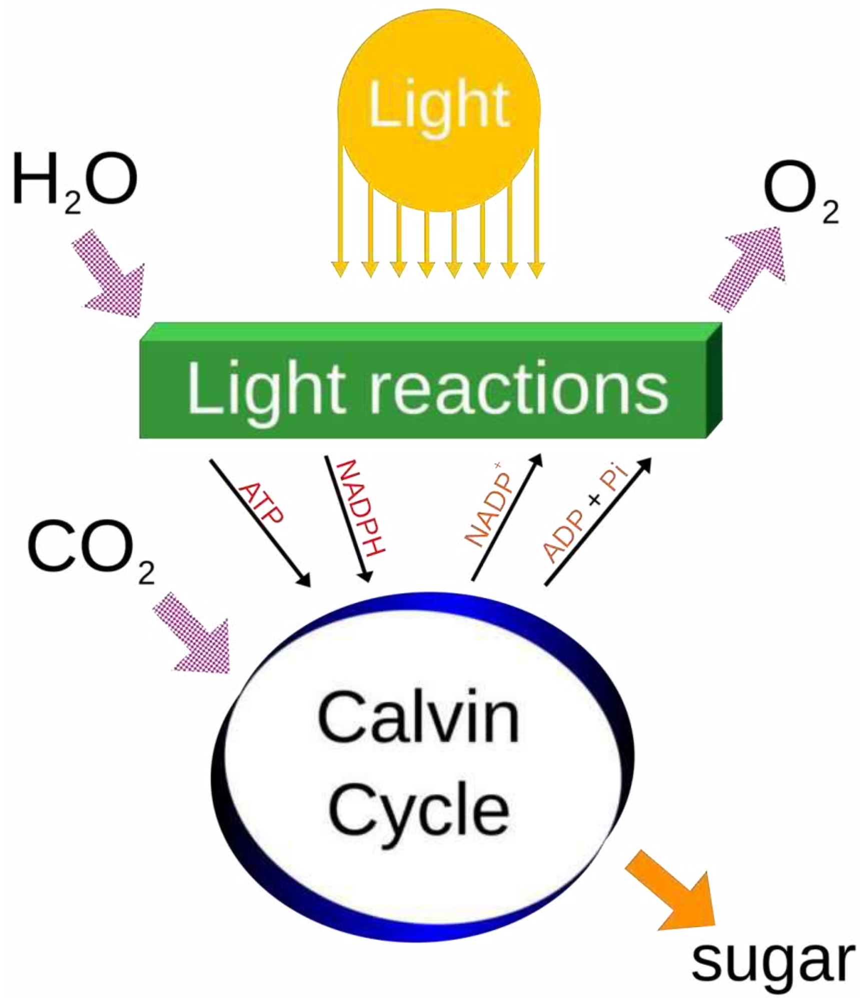
Nutrient recycling - Biogeochemical Cycles

Development and Stabilization - Associations, Adaptations, Succession

Productivity - Food Production

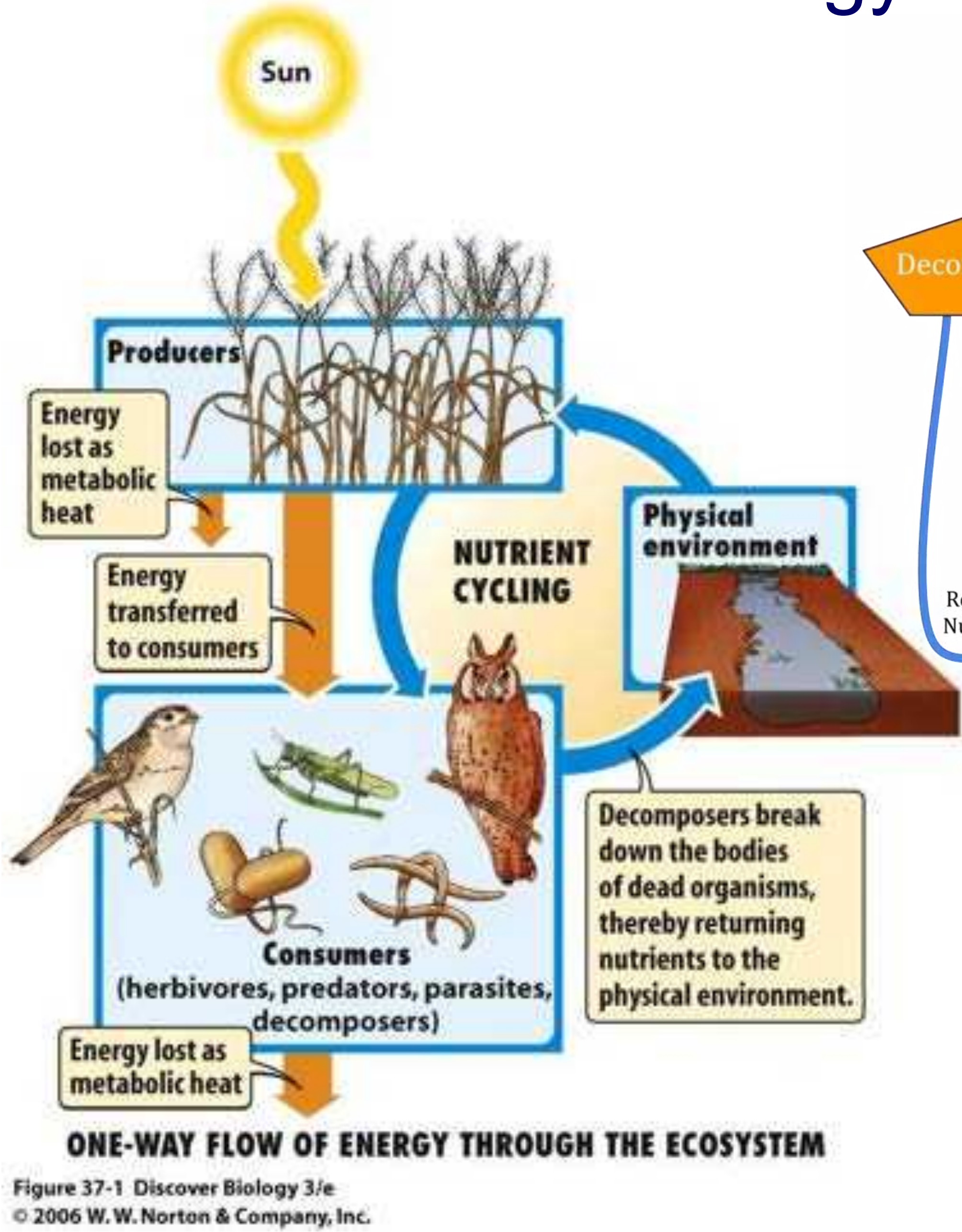


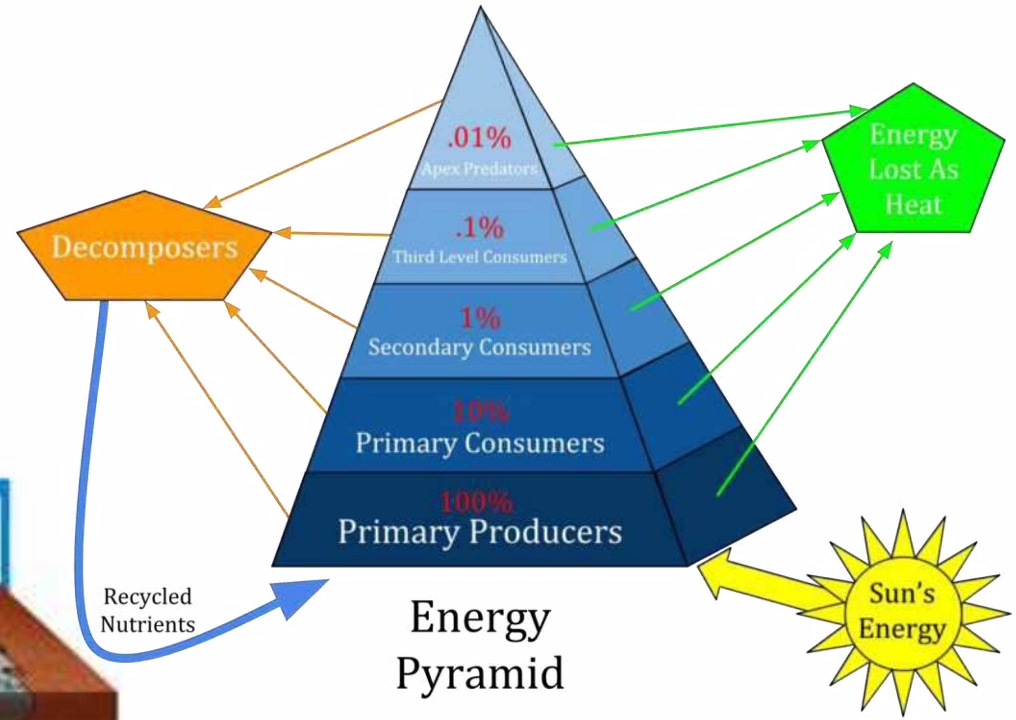
https://upload.wikimedia.org/wikipedia/commons/a/a2/Photosynthesis_Block_diag.gif



https://en.wikipedia.org/wiki/Photosynthesis

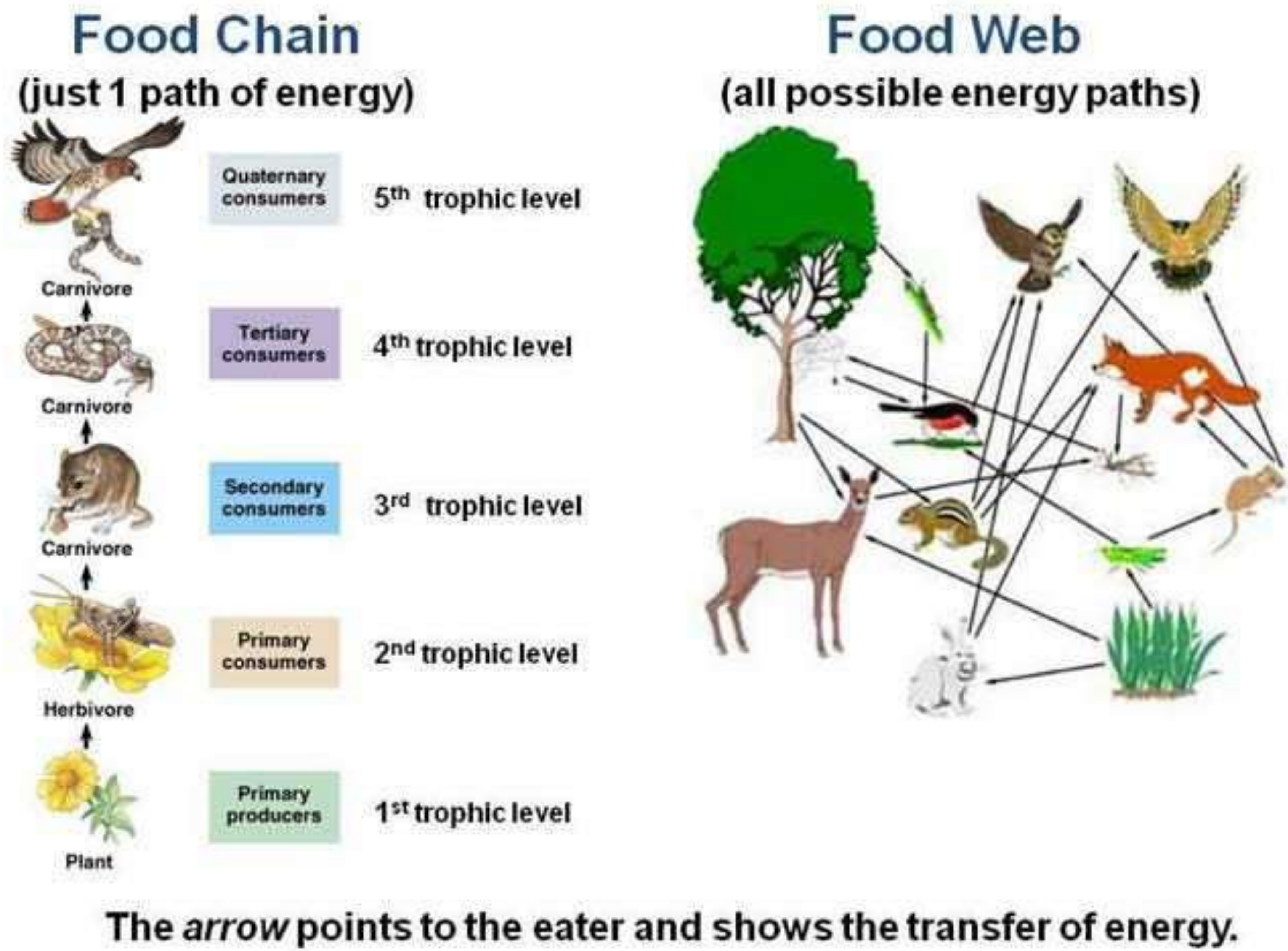
Energy Flow





https://upload.wikimedia.org/wikipedia/commons/thumb/3/3a/Ecological_Pyramid.svg/2000px-Ecological_Pyramid.svg.png

https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcRzjOz_0Z0hjtz-ioqM43GrS3M9qDzOnXmtwQPp0BA6TFDfDpFC7g



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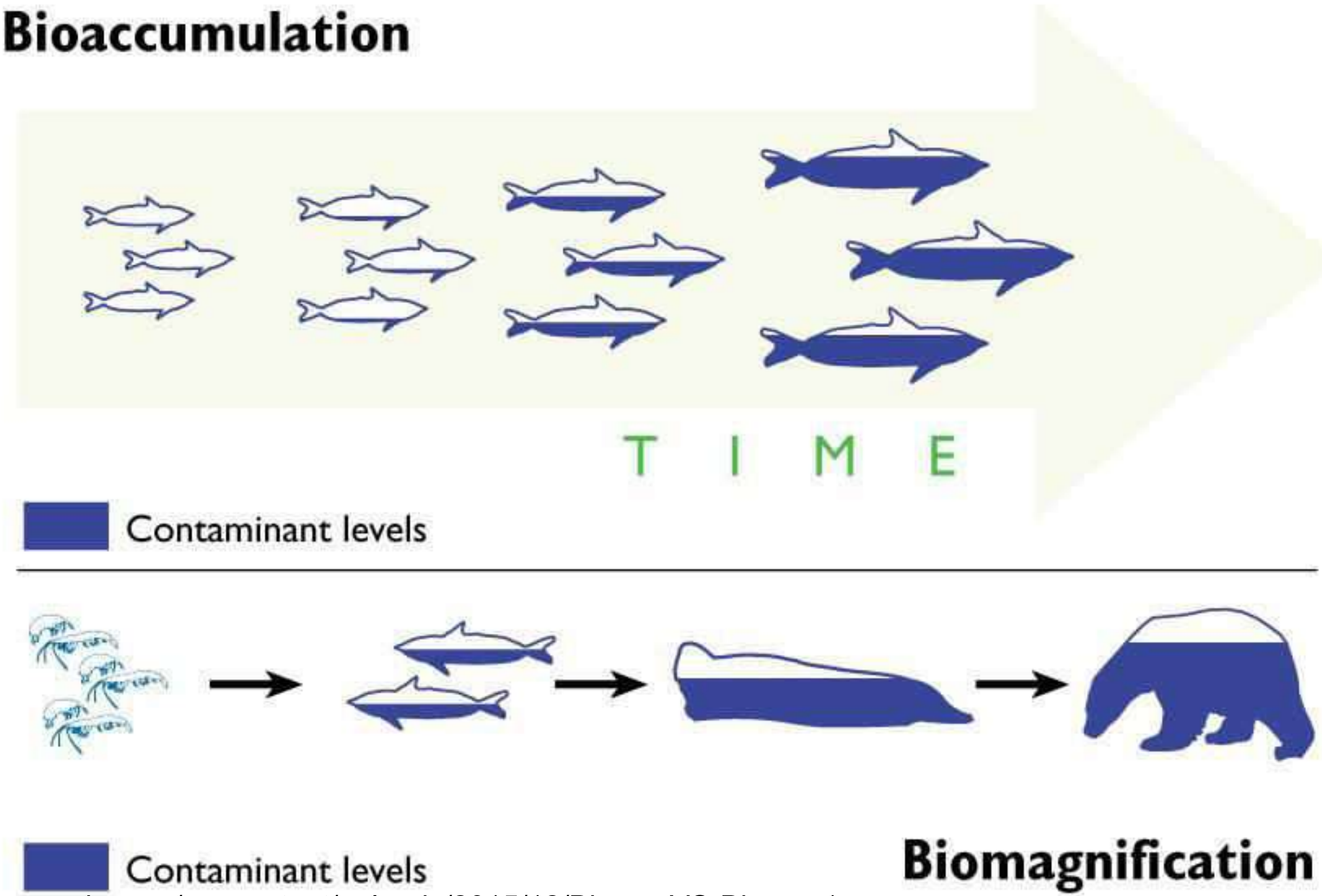
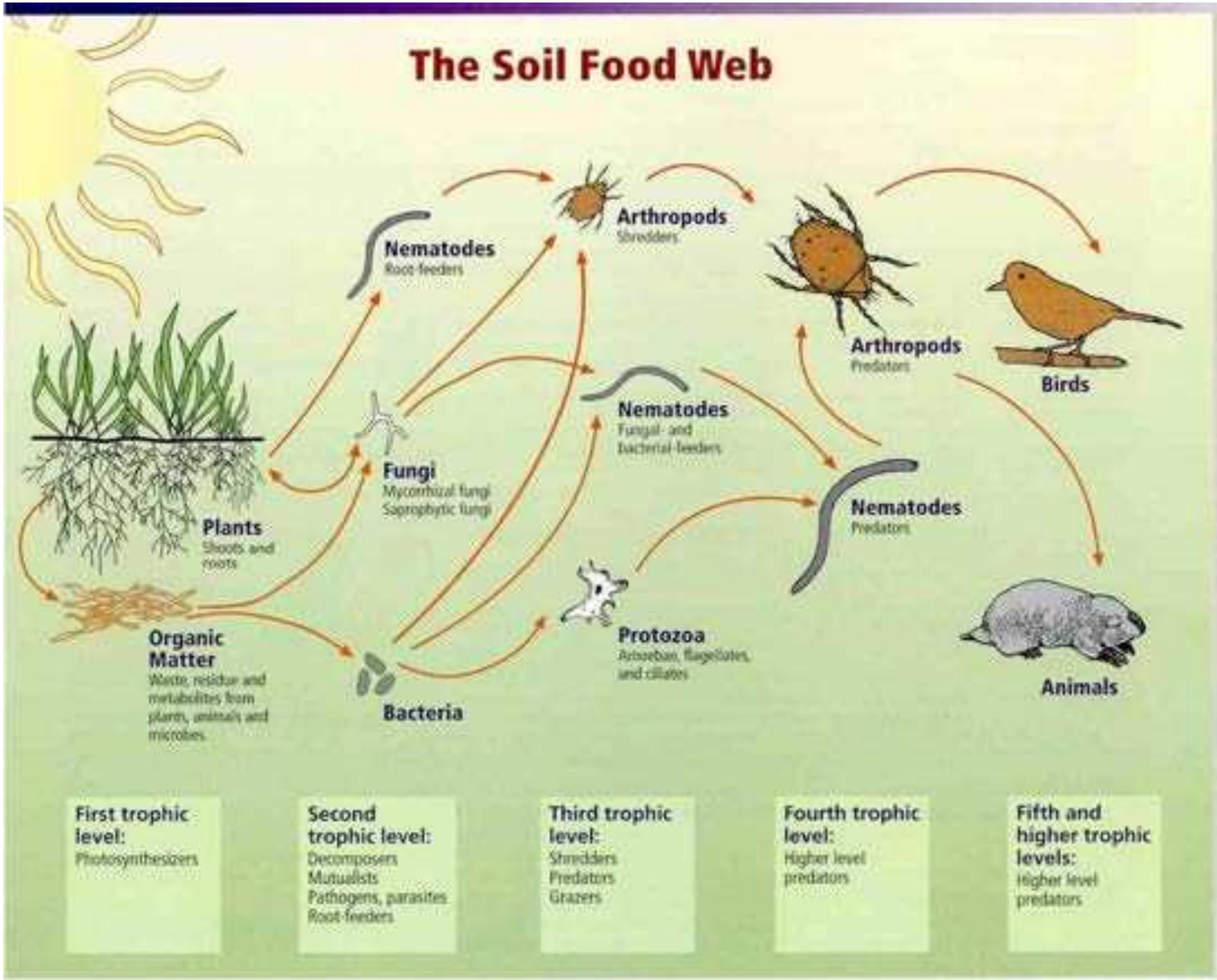
Flow of Chemical and Pollutants through Food Chain



http://iasmania.com/wp-content/uploads/2015/12/Bioacc-VS-Biomag1.png

Detritus Food Chain

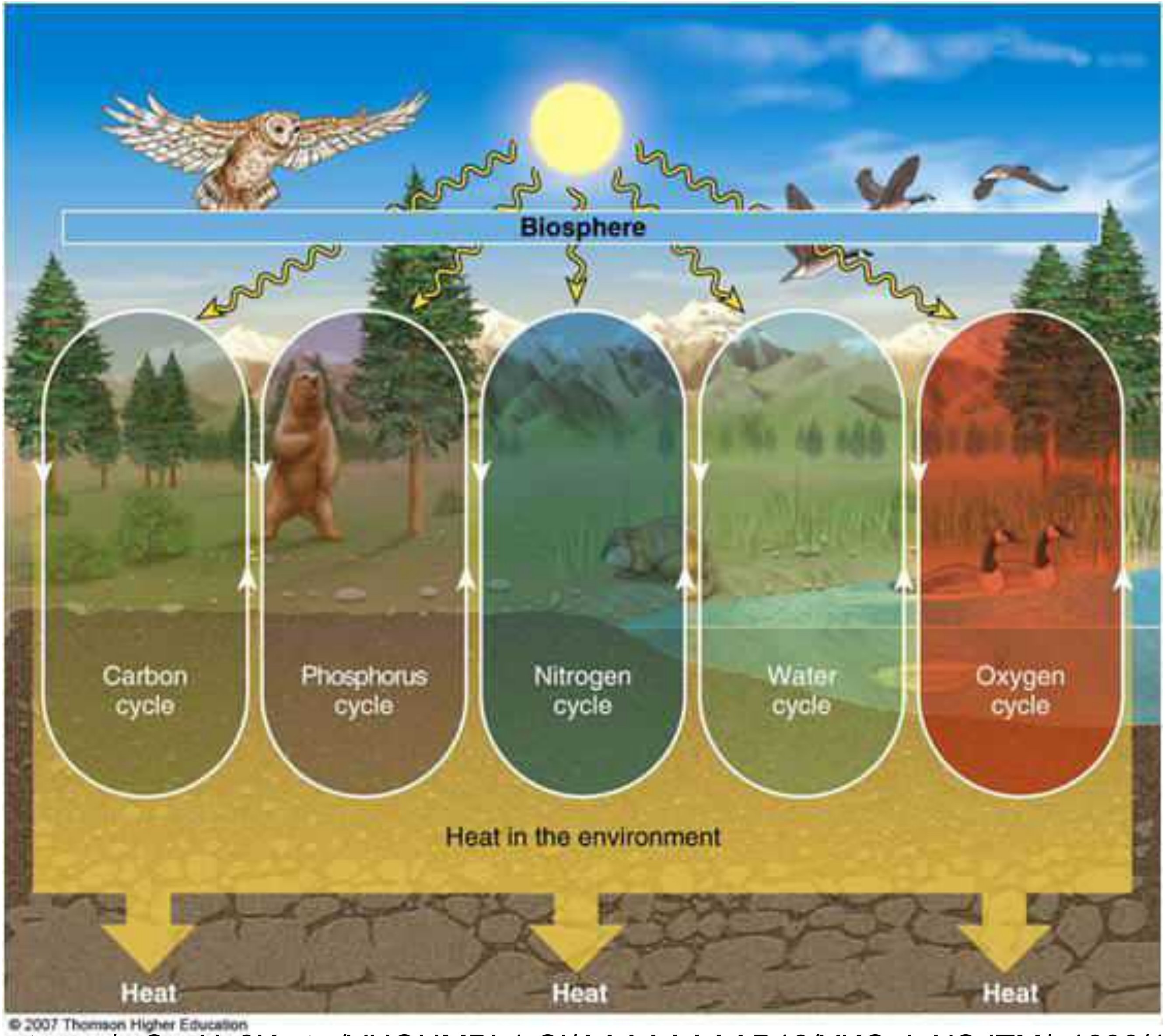
- Less dependent on direct sunlight
- Depends on influx of organic matter from another system
- Generally small
- E.g. Mangrove leaves (detritus)—microorganisms—crabs
- E.g. Caves: bat colonies—guano—organisms (salamanders)
- E.g. Ocean floor—dead carcasses—organisms feeding on it.



Relationships between soil food web, plants, organic matter, and birds and mammals
Image courtesy of USDA Natural Resources Conservation Service
http://soils.usda.gov/sqi/soil_quality/soil_biology/soil_food_web.html.

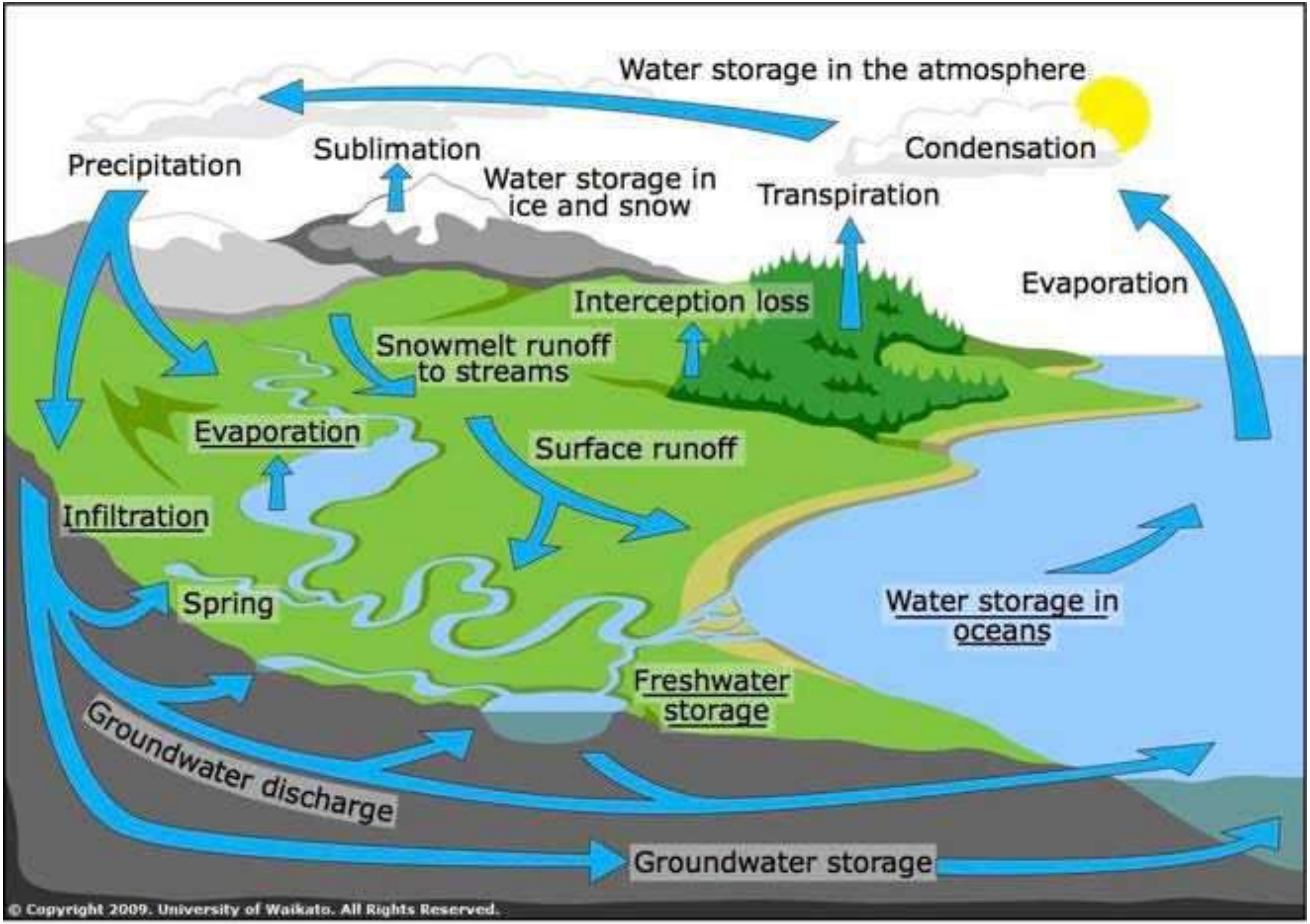
https://en.wikipedia.org/wiki/Food_web

Nutrient recycling - Biogeochemical Cycles



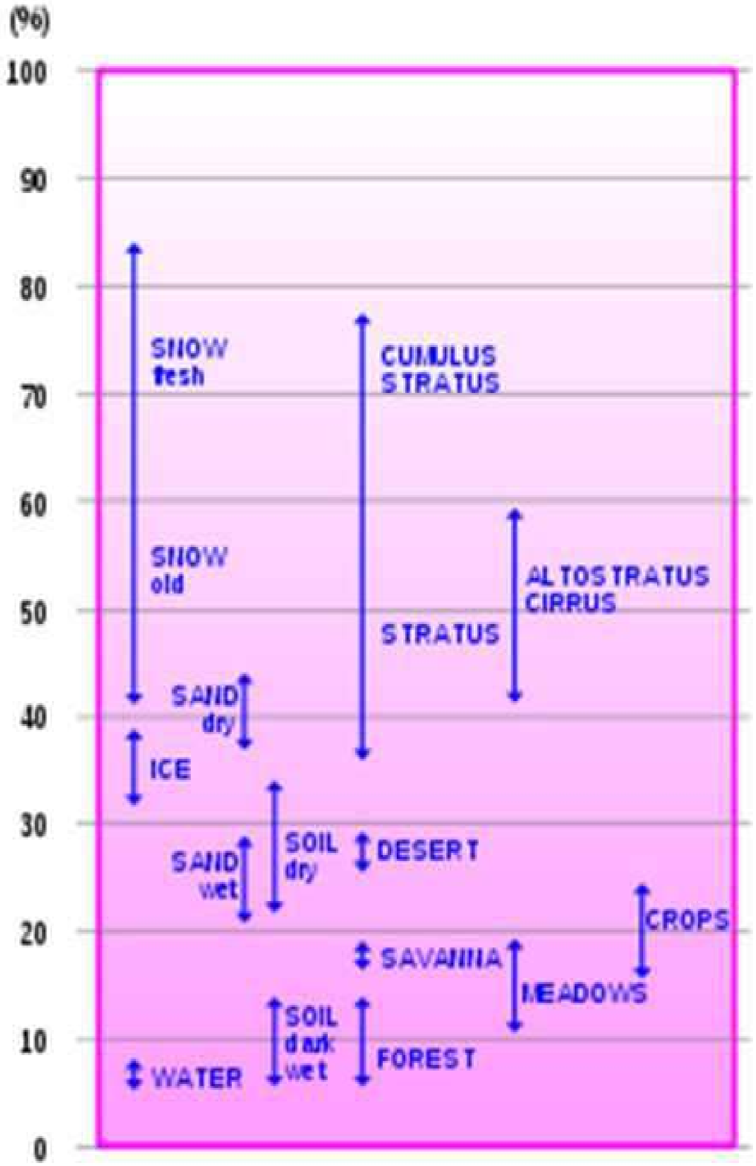
http://1.bp.blogspot.com/-sSscHv8Kmtw/VUQHMBL1rSI/AAAAAAAAB18/YKOpIqNSdTM/s1600/1A%2B-%2BBiogeochemical%2BCycle%2BComponents.jpg

Hydrological Cycle



Hydrological Cycle & Earth's Albedo

- Evaporation—cloud formation
- Increased albedo or *reflection coefficient* is a measure of the 'whiteness' of the earth when viewed through space.
- Greater the albedo→lower is the solar radiation absorbed by the earth→lower is the temperature of the globe (Greater cooling).



https://upload.wikimedia.org/wikipedia/commons/thumb/1/18/Albedo-e_hg.svg/549px-Albedo-e_hg.svg.png

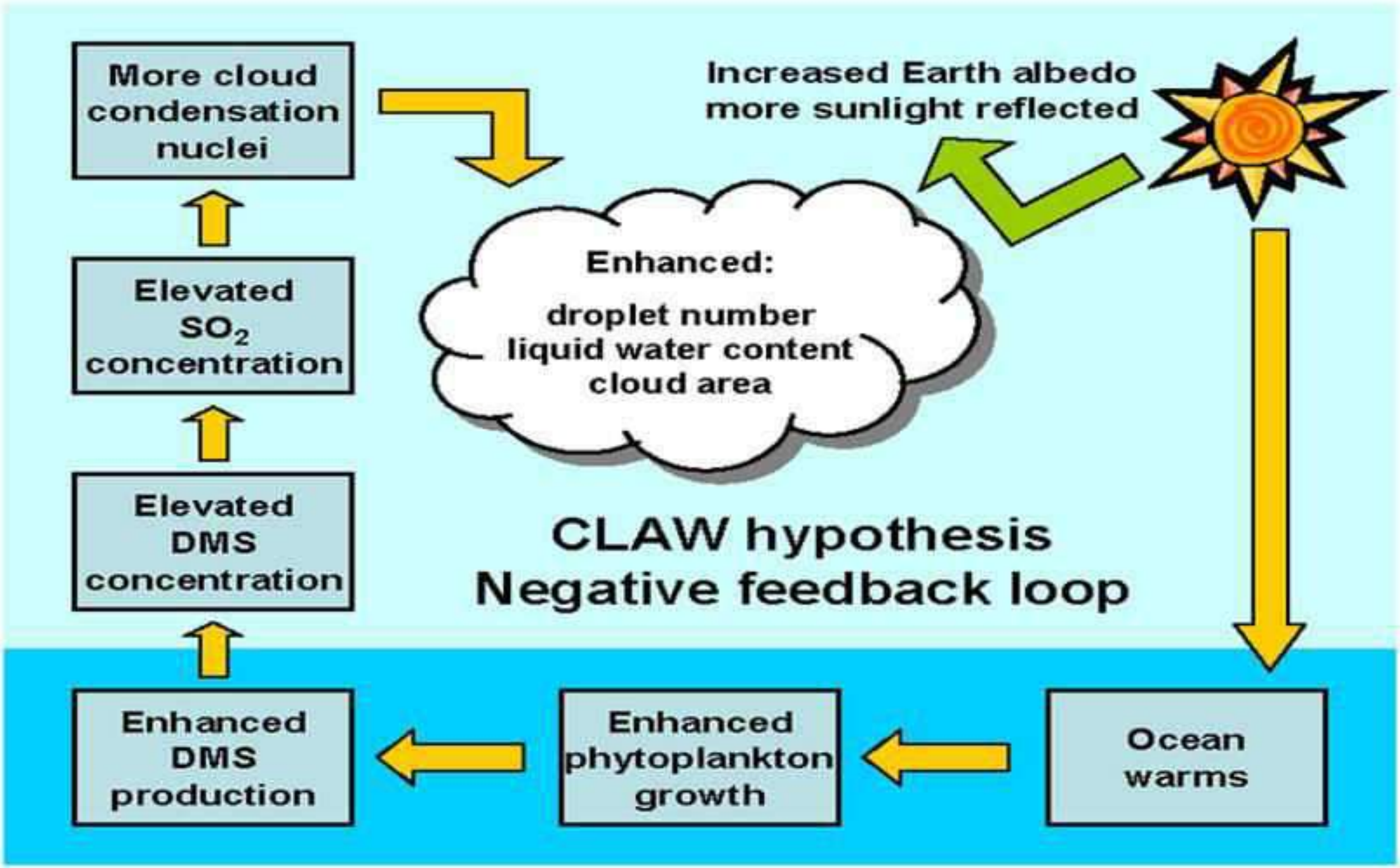
Albedo and Tree Cover

- Trees tend to have a low albedo
  - Deciduous trees: 0.15-0.18 (15-18%)
  - Coniferous trees 0.09-0.15 (9-15%)
- Hence, removing forests → increases albedo →localized climate cooling.
- However, trees also provide local evaporative cooling and carbon sequestration; loss of trees reduces these cooling effects.
- Cloud feedbacks and snow cover further complicate the issue.
- Studies of new forests indicate:
  - A net cooling effect in tropical and mid-latitude areas
  - A net neutral or slightly warming effect in high latitudes (e.g. Siberia)

- Betts, Richard A. (2000). "Offset of the potential carbon sink from boreal forestation by decreases in surface albedo". *Nature* **408** (6809): 187–190. doi:10.1038/35041545.PMID 11089969.

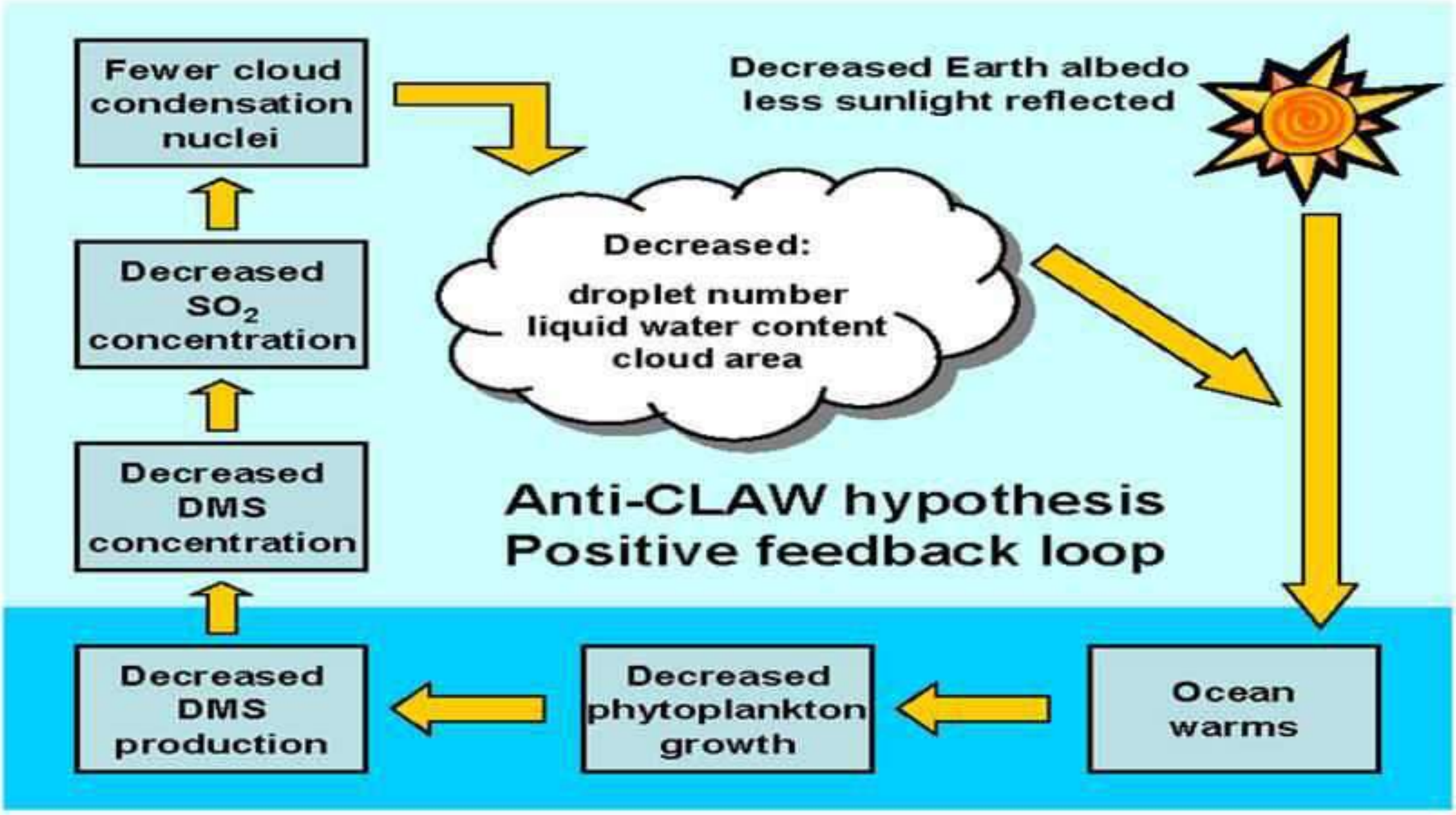
Phytoplankton, Clouds, Albedo

- Phytoplankton produce dimethylsulfoniopropionate (DMSP)
- Converted to Dimethyl sulfide (DMS) in ocean
- Escapes to atmosphere, oxidizes to SO_2 and nucleates clouds.
- This is an example of how the biosphere (plankton) regulates the hydosphere (global precipitation), earth’s albedo and global temperature.
- **CLAW Hypothesis:** negative feedback; regulation of global temperature.
- **Anti-CLAW Hypothesis:** positive feedback; escalation of global warming.



warm oceans→more phytoplankton → more DMS → More clouds → cooling (negative feedback; regulation)

https://upload.wikimedia.org/wikipedia/en/thumb/f/f5/CLAW_hypothesis_graphic_1_AYool.png/598px-CLAW_hypothesis_graphic_1_AYool.png



warm oceans → stalling of thermohaline ocean currents→ocean stratification → less nutrients from ocean bottom in euphotic zone → less phytoplankton → less DMS → less clouds → more heating (positive feedback; escalation)

https://upload.wikimedia.org/wikipedia/en/c/cc/CLAW_hypothesis_graphic_2_AYool.png

Plants: Significance in Water Cycle

- Taproots go upto 100x deeper than canopy
- Short-circuit pathways for soil water redistribution
- In dry spells, water from below brought to surface, to increase nutrient extraction, photosysnthesis and transpiration.
- In wet spells, promote percolation

Plants: Significance in Water Cycle

- Plants pump huge quantities of water from soil to air.
  - 100s to 1000s L/day
  - Regulate T and humidity. In a clearing in Nigeria, soil T upto 5°C higher; humidity reduced by 50% compared to adjacent forest.
- Evapo-transpiration of trees—nature's pump and cooler
- Drop in Amazon's temperature in June/July is due to transpiration.
- Transpiration: 40% of Amazonian rain is from transpiration
- Afforestation efforts: appropriate types and density.

●/http://www.i-sis.org.uk/LOG4.php

Importance of Rainforests

- 25% of rain never reaches the ground.; wets canopy and evaporates
- 25% of total—runoff
- 50% of total pumped up and transpired by plants.
- 75% of rainwater is returned to the atmosphere; new clouds, new rain,
- Colossal heat pump—energy of six million atom bombs/day; redistributes energy to higher latitudes
- Up to 80% incident solar energy carried by hot, humid air;
    - rises rapidly and develops into thunder clouds that simultaneously
    - ater areas further downwind
    - releases latent heat

Importance of Rainforests

- Absorb 2 billion tonnes of CO_2/yr; about 20-30% of fossil C emissions
- Destruction of the Amazon:
    - May stall the heat pump
    - Accelerate drought and desertification (positive feedback)
    - Loss of CO_2 sink; accelerate global warming.
    - Reforestation cannot replace natural stands. Loss of soil carbon.

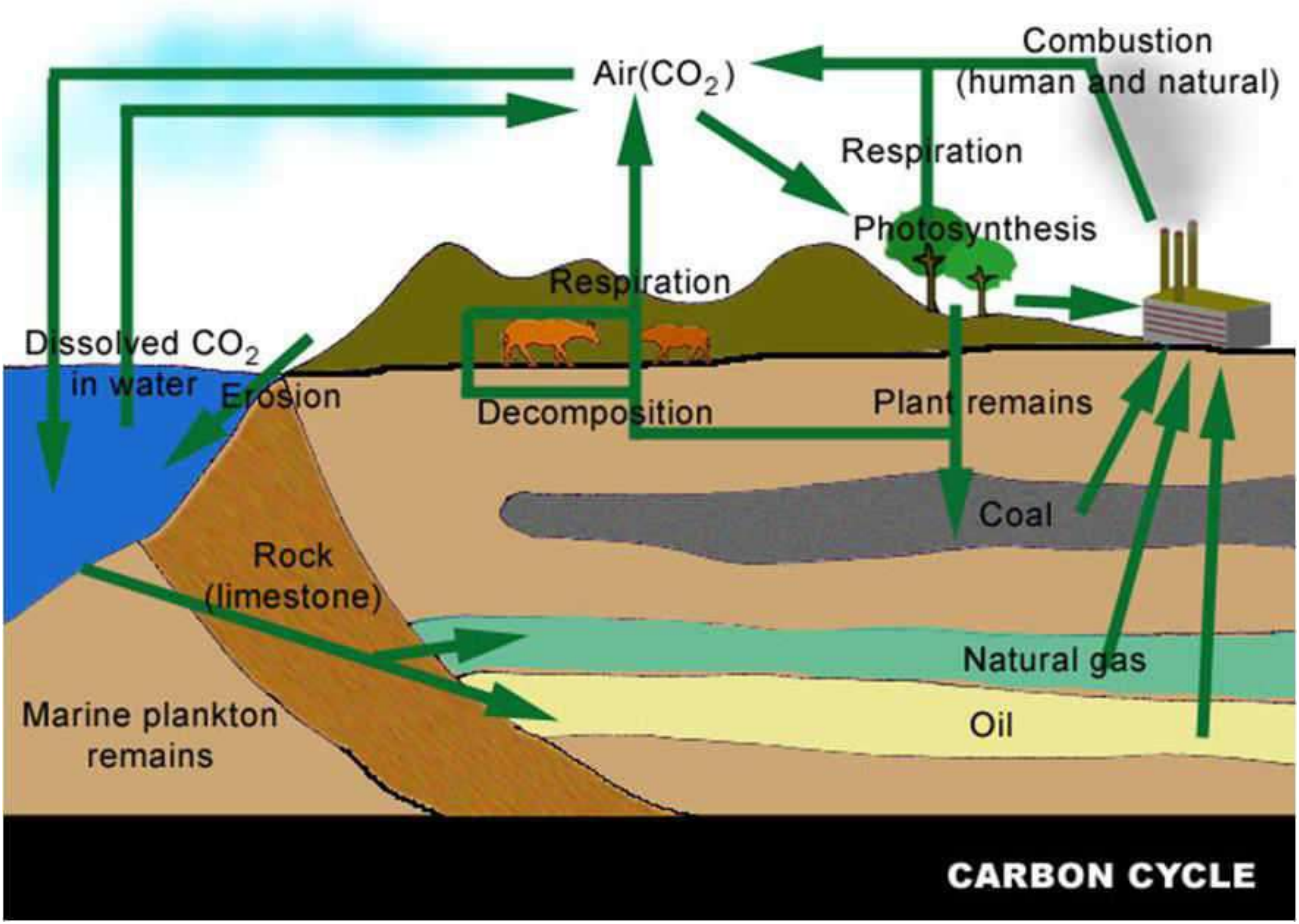
Sources:
Prof. Eneas Salati from the University of São Paulo, Piracicaba – Brasil http://www.fgaia.org.br/texts/e-rainforests.html
http://www.hydrogen.co.uk/h2_now/journal/articles/1_global_warming.htm
http://www.hydrogen.co.uk/h2_now/journal/articles/2_global_warming.htm
http://www.greendiary.com/entry/increasing-global-warming-decreases-forests-co2-absorption-capacity
http://www.i-sis.org.uk/LOG4.php

Human impacts on hydrologic cycle

- Damming rivers increases evaporation and infiltration
- Altering the surface and vegetation increases runoff and erosion
- Spreading water on agricultural fields depletes rivers, lakes and streams
- Removing forests and vegetation reduces transpiration and lowers water tables
- Emitting pollutants changes the nature of precipitation
- The most threatening impact is overdrawing groundwater for drinking, irrigation, and industrial use

Availability of Carbon

- Earth's C content = 0.19% (0.032% in lithosphere)
- Atmospheric CO_2 is the main utilizable reservoir
- 18% in biomass
- Main reservoirs air, rocks (carbonates), oceans.



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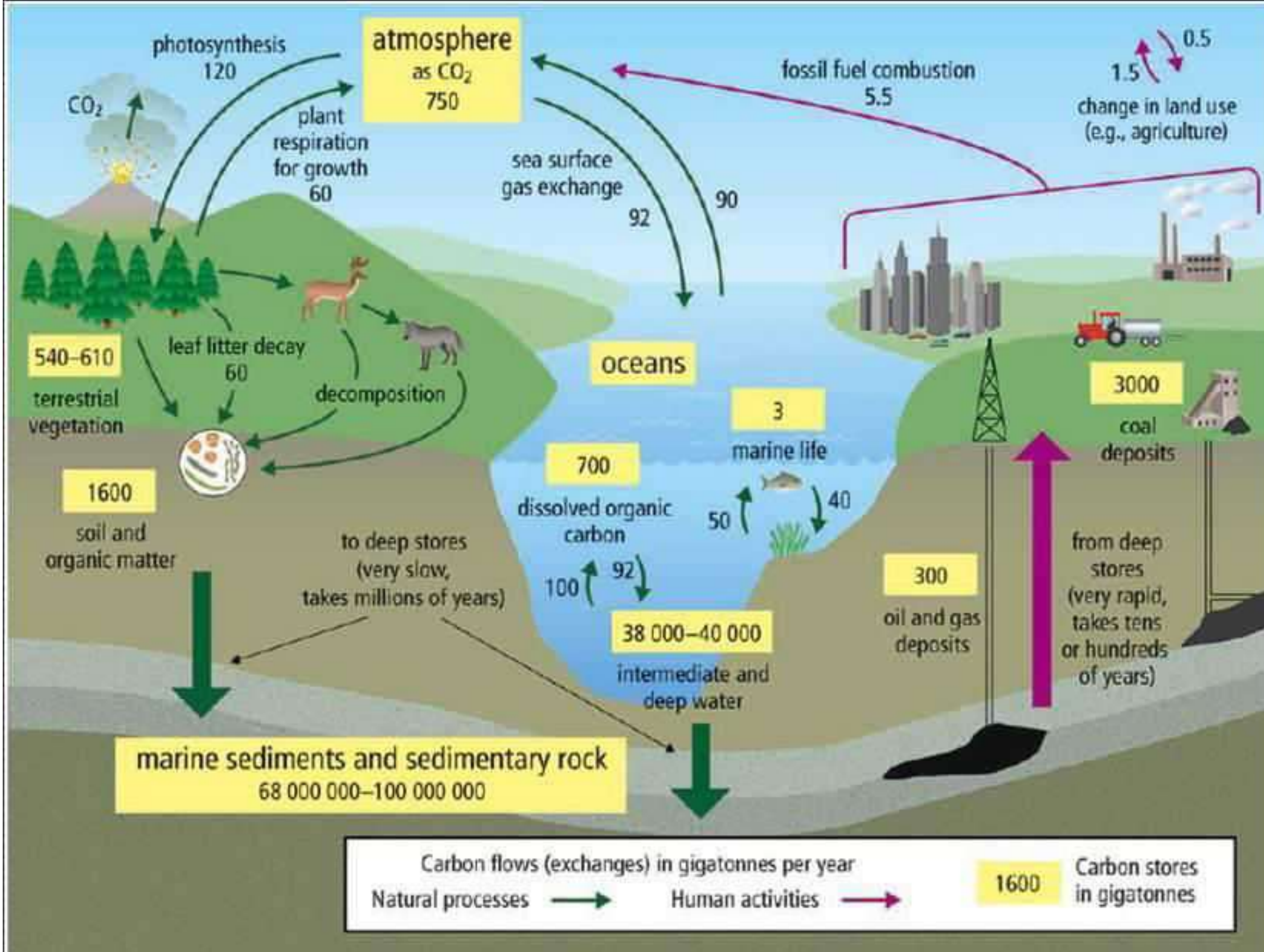

atmosphere
as CO_2
750
photosynthesis
120
CO_2
plant
respiration
for growth
60
sea surface
gas exchange
92
90
fossil fuel combustion
5.5
1.5
0.5
change in land use
(e.g., agriculture)
540–610
terrestrial
vegetation
leaf litter decay
60
decomposition
oceans
3
marine life
3000
coal
deposits
1600
soil and
organic matter
700
dissolved organic
carbon
50
40
100
92
to deep stores
(very slow,
takes millions of years)
38 000–40 000
intermediate and
deep water
300
oil and gas
deposits
from deep
stores
(very rapid,
takes tens
or hundreds
of years)
marine sediments and sedimentary rock
68 000 000–100 000 000
Carbon flows (exchanges) in gigatonnes per year
Natural processes
Human activities
1600
Carbon stores
in gigatonnes

Potential contributors to climate change

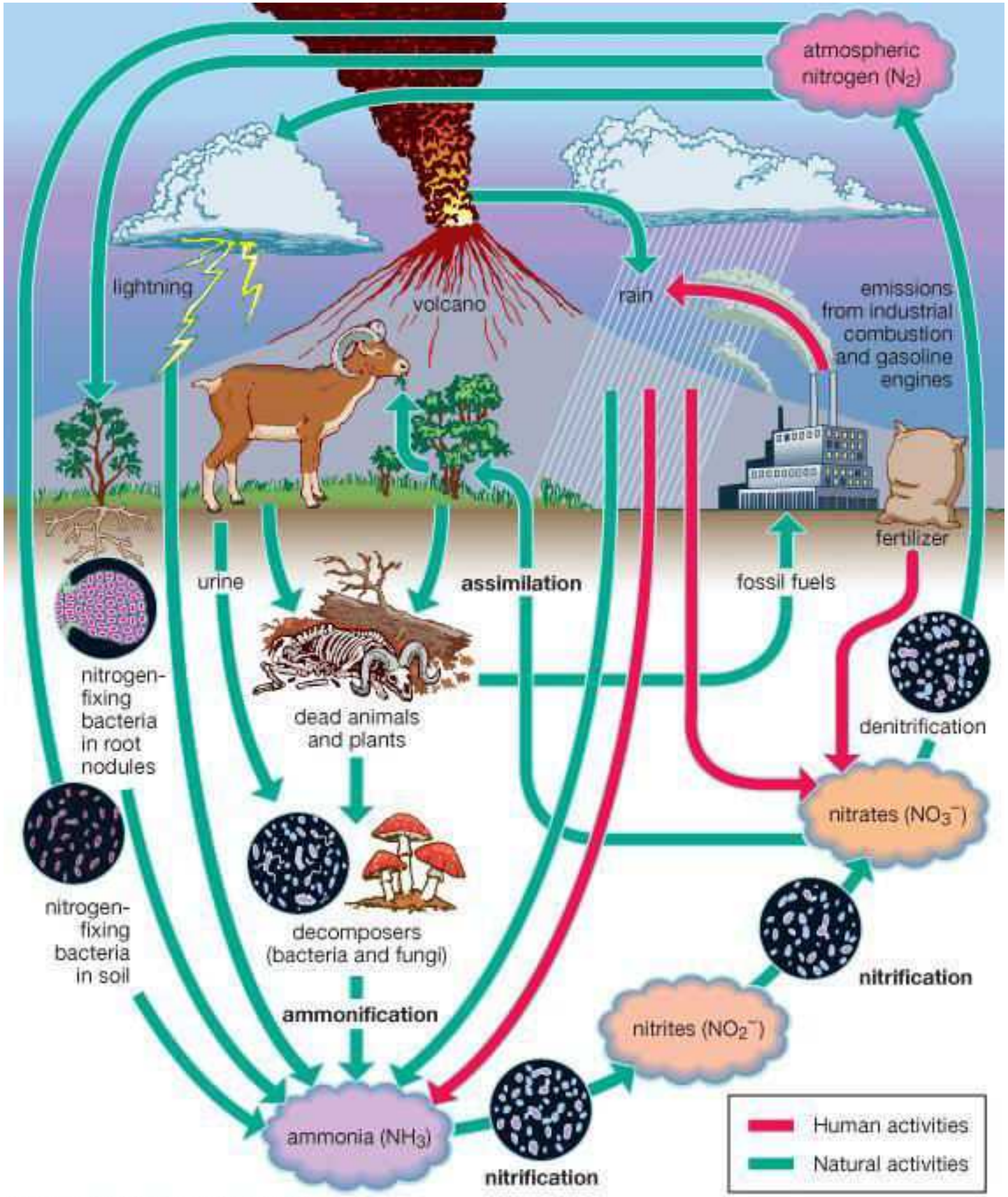
- Complex interactions in the climate puzzle
- Feedback mechanisms
- Some interesting twists
    - Increasing temp. reduces CO_2 solubility (reduced C-sink capacity of the ocean)
    - Ocean Acidification reduces C-sequestration in the form of $CaCO_3$
    - 740ppm CO_2 in water by 2100. Reduction in population of mussels by 25% and oysters by 10%
    - At 1800ppm, shells will dissolve

Human Impacts on Carbon Cycle

- Burning of Fossil fuels
- Deforestation and Poor Agricultural practices
- Increase in atmospheric greenhouse gasses such as CO_2, methane, SO_X, NO_X, etc. leads to Greenhouse effect, global warming and climate change.

Nitrogen Reservoir

- N is an essential component of proteins, nucleic acids and other cellular constituents.
- **Reservoirs –** 79% of the atmosphere is N_2 gas.
- The N$\equiv$N triple bond is relatively difficult to break, requires special conditions. As a result most ecosystems are N-limited.
- N_2 dissolves in water, cycles through air, water and living tissue.


atmospheric nitrogen (N_2)
lightning
volcano
rain
emissions from industrial combustion and gasoline engines
urine
assimilation
fossil fuels
fertilizer
nitrogen-fixing bacteria in root nodules
dead animals and plants
denitrification
nitrates (NO_3^-)
nitrogen-fixing bacteria in soil
decomposers (bacteria and fungi)
ammonification
nitrification
nitrites (NO_2^-)
ammonia (NH_3)
nitrification
Human activities
Natural activities

Nitrogen Fixation

- Abiotic: lightning (very high T and P) 10^7 metric tons yr^{-1} ~ 5-8% of total annual N fixation. (weathering of rocks is insignificant)
- Biotic: Nitrogen fixation by microbes, 1.75 $x10^8$ metric tons yr^{-1} (symbiotic bacteria: *azobacter* or *rhizobium*- legumes
- Industrial: The Haber-Bosch process (1909) $5x10^7$ metric tons yr^{-1} – high P & T, Fe catalyst to convert N_2 to NH_3; & NH_4NO_3
- Combustion Side Effect: $2x10^7$ metric tons yr^{-1}. High T and P oxidizes N_2 to NO_x

Nitrification-Denitrification

- **Nitrification** by chemoautotrophs
  - Bacteria of the genus *Nitrosomonas* oxidize NH_3 to NO_2^-
  - Bacteria of the genus *Nitrobacter* oxidize the nitrites to NO_3^-
- **Denitrication** Anaerobic respiration of NO_3^- to dinitrogen gas by several species of *Pseudomonas*, *Alkaligenes*, and *Bacillus*

Human Impacts on Nitrogen Cycle

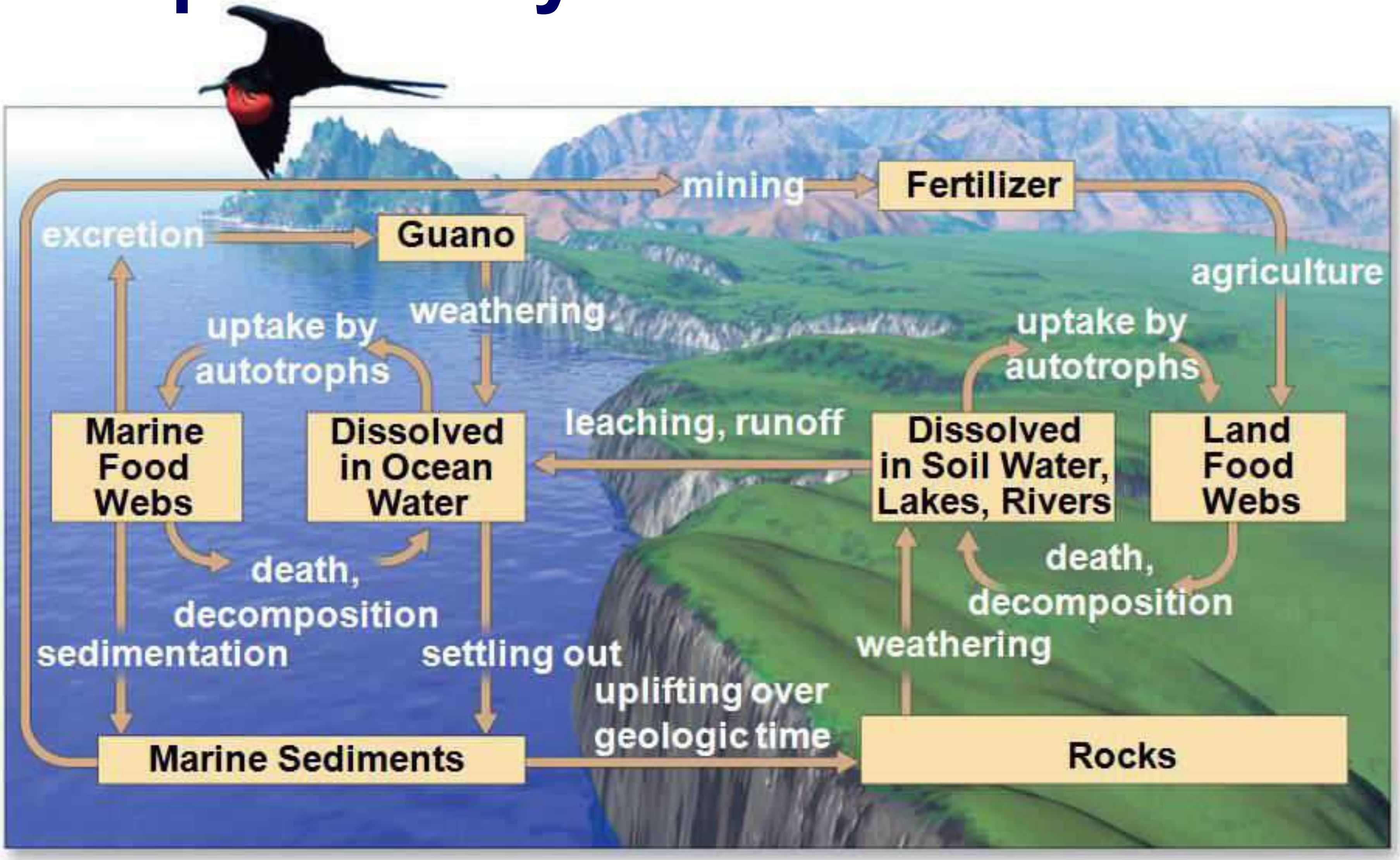
- Burning of Fossil fuels add Nitrogen Oxides (NO_2) and Nitric Acid vapor (HNO_3).
- Nitrous Oxide (N_2O) released by the action of anaerobic bacteria on Livestock waste.
- Nitrogen stored in Soil and Plants released by destruction of forestlands, grassland and wetlands.
- Upset the nitrogen cycle in aquatic ecosystem by adding excess of nitrates to the body
- Harvest nitrogen-rich crops, irrigate crops, wash out nitrogen from topsoils

Fate of N

- **Sources of anthropogenic N loads:** Fertilizers, Legume Crops, Combustion and forest burning, livestock.
- In most terrestrial and freshwater ecosystems N is a limiting nutrient, gets cycled efficiently.
- What happens when plants have enough N (i.e. greater 16:1 N:P ratio)?
- When N saturation of ecosystem occurs, excess N tends to leave the system in the form of nitrate.
- Flushing/erosion – dissolved and particulate matter in streamwater, (DIN, DON, TN, Org N)
- Leaching to groundwater – NO_3^- poor sorption to clays, highly water soluble.

- Selective pressures in terrestrial systems favoring species-poor grasslands and forests
- Nitrate MCL – 10 mg/L …
- Nitric oxide – precursor of acid rain and smog
- Nitrous oxide – long lived greenhouse gas that can trap 200 times as much heat as CO_2

Phosphorus Cycle



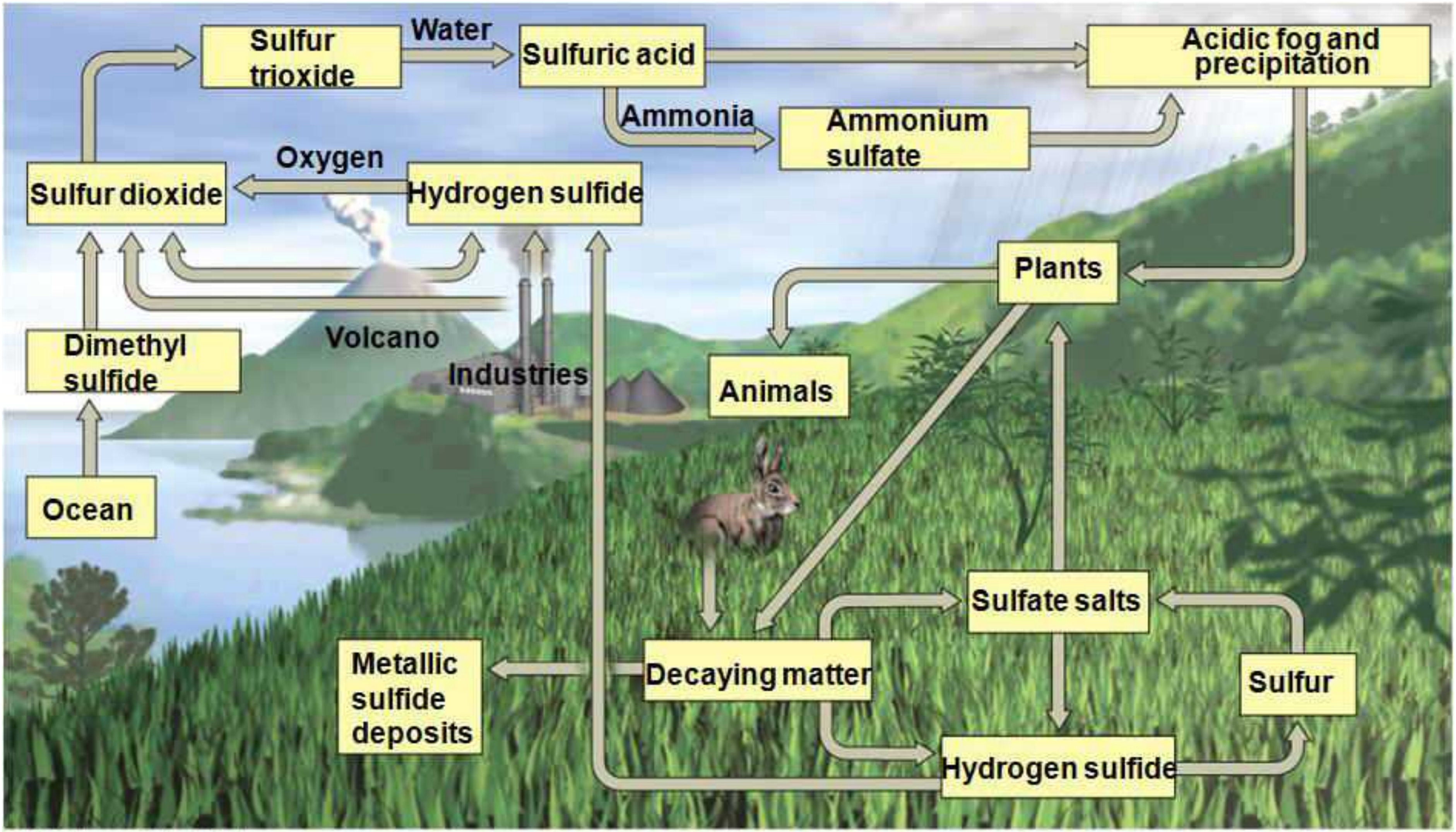
Ref

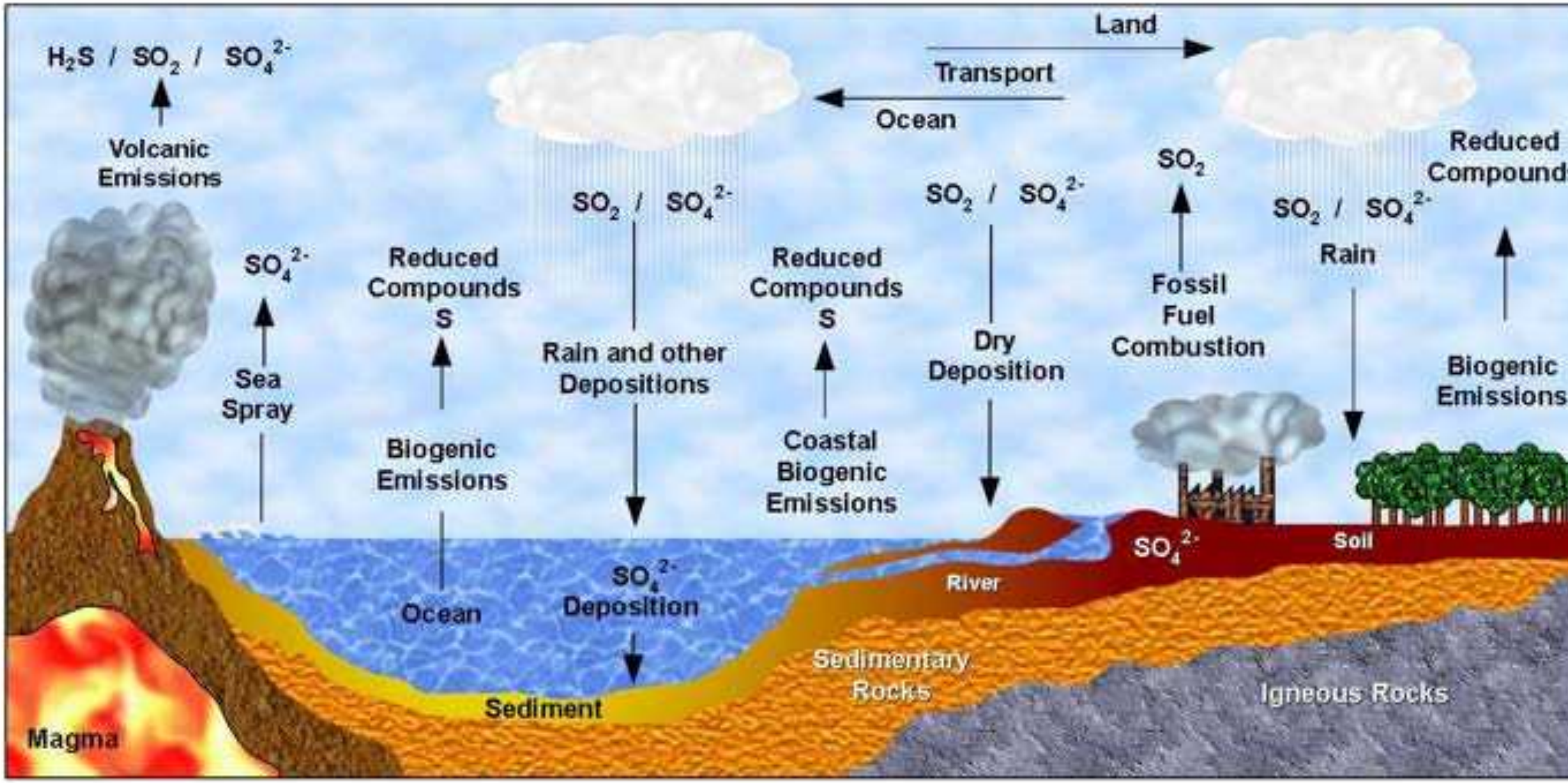
- One of the longest cycles
- Essential nutrient; DNA, ATP, ADP, fat, cell membranes

Human Impacts on Phosphorus Cycle

- P-containing detergents
- Mining phosphate rock
- P-containing fertilizer use
- P in water leads to eutrophication

Sulphur Cycle





H_2S / SO_2 / SO_4^{2-}
Volcanic Emissions
Land
Transport
Ocean
SO_2 / SO_4^{2-}
SO_2 / SO_4^{2-}
SO_2
Reduced Compounds
SO_2 / SO_4^{2-}
SO_4^{2-}
Reduced Compounds S
Reduced Compounds S
Rain
Fossil Fuel Combustion
Dry Deposition
Rain and other Depositions
Sea Spray
Biogenic Emissions
Biogenic Emissions
Coastal Biogenic Emissions
SO_4^{2-}
Soil
River
SO_4^{2-} Deposition
Ocean
Sedimentary Rocks
Igneous Rocks
Sediment
Magma

Human Impacts on Sulfur Cycle

- SO_2 from industry and combustion (e.g. coal, petrol).

- SO_2 from Refine industry convert the Petroleum

to Gasoline Products

- SO_2 from Metallic ore Industries.
- SO_2 from Mining industries - Acid mine drainage

- Self regulation: chemistry of oceans, atmosphere, temperature, living beings
- Earth behaves as if it had a purpose
- Purpose is to nurture life and maintain life-friendly conditions.
- This perspective brings a new awareness that can be the foundation of all future development
- It will enable the further evolution of mankind

Ecosystem Services ref

Ecosystem 'services' are provided free-of-charge as a gift of nature.

- purification of air and water
- regulation of rainwater run-off and drought
- waste assimilation and detoxification
- soil formation and maintenance
- control of pests and disease
- plant pollination, seed dispersal and nutrient cycling

- maintaining biodiversity for agriculture, pharmaceutical research and development and other industrial processes
- protection from harmful ultraviolet radiation
- climate stabilization (for example, though carbon sequestration)
- moderating extremes of temperature, wind, and waves.

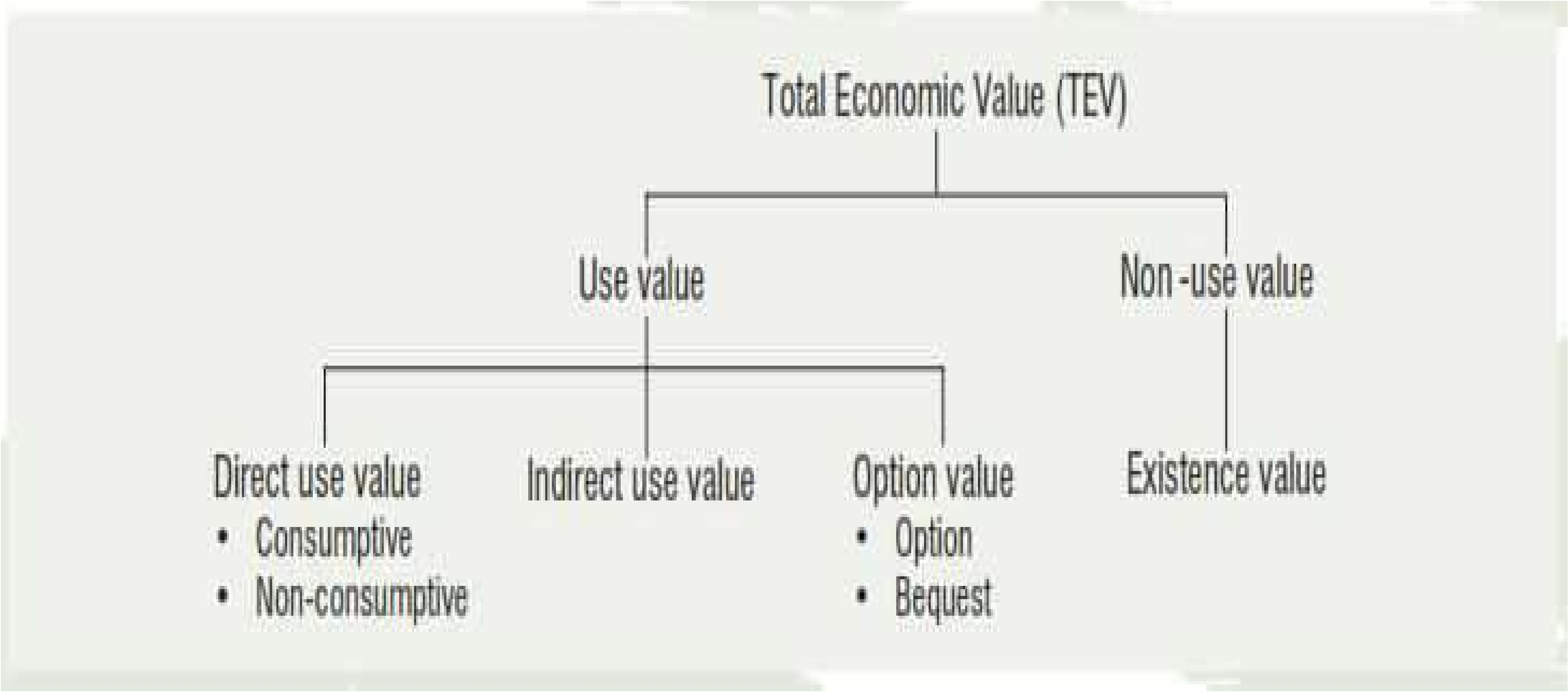
Major Ecosystem Types and Services ref

Ecosystem service	Ecosystem									
	Cultivated	Dryland	Forest	Urban	Inland Water	Coastal	Marine	Polar	Mountain	Island
Freshwater			•		•	•		•	•	
Food	•	•	•	•	•	•	•	•	•	•
Timber, fuel, and fiber	•		•			•				
Novel products	•	•	•		•		•			
Biodiversity regulation	•	•	•	•	•	•	•	•	•	•
Nutrient cycling	•	•	•		•	•	•			
Air quality and climate	•	•	•	•	•	•	•	•	•	•
Human health		•	•	•	•	•				
Detoxification		•	•	•	•	•	•			
Natural hazard regulation			•		•	•			•	
Cultural and amenity	•	•	•	•	•	•	•	•	•	•

Source: https://www.cbd.int/doc/case-studies/inc/cs-inc-iucn-nc-wb-en.pdf

Economic Value of Ecosystem Services ref

Economists typically classify ecosystem goods and services according to how they are used



Source: https://www.cbd.int/doc/case-studies/inc/cs-inc-iucn-nc-wb-en.pdf

Direct use values:

<u>Consumptive uses</u> <u>ref</u>

harvesting of food products

timber for fuel or construction

medicinal products

hunting of animals for consumption

<u>non-consumptive uses</u> ref

enjoyment of recreational and cultural activities

that do not require harvesting of products

Indirect use values ref: from ecosystem services

Natural water filtration - which often benefits people far downstream

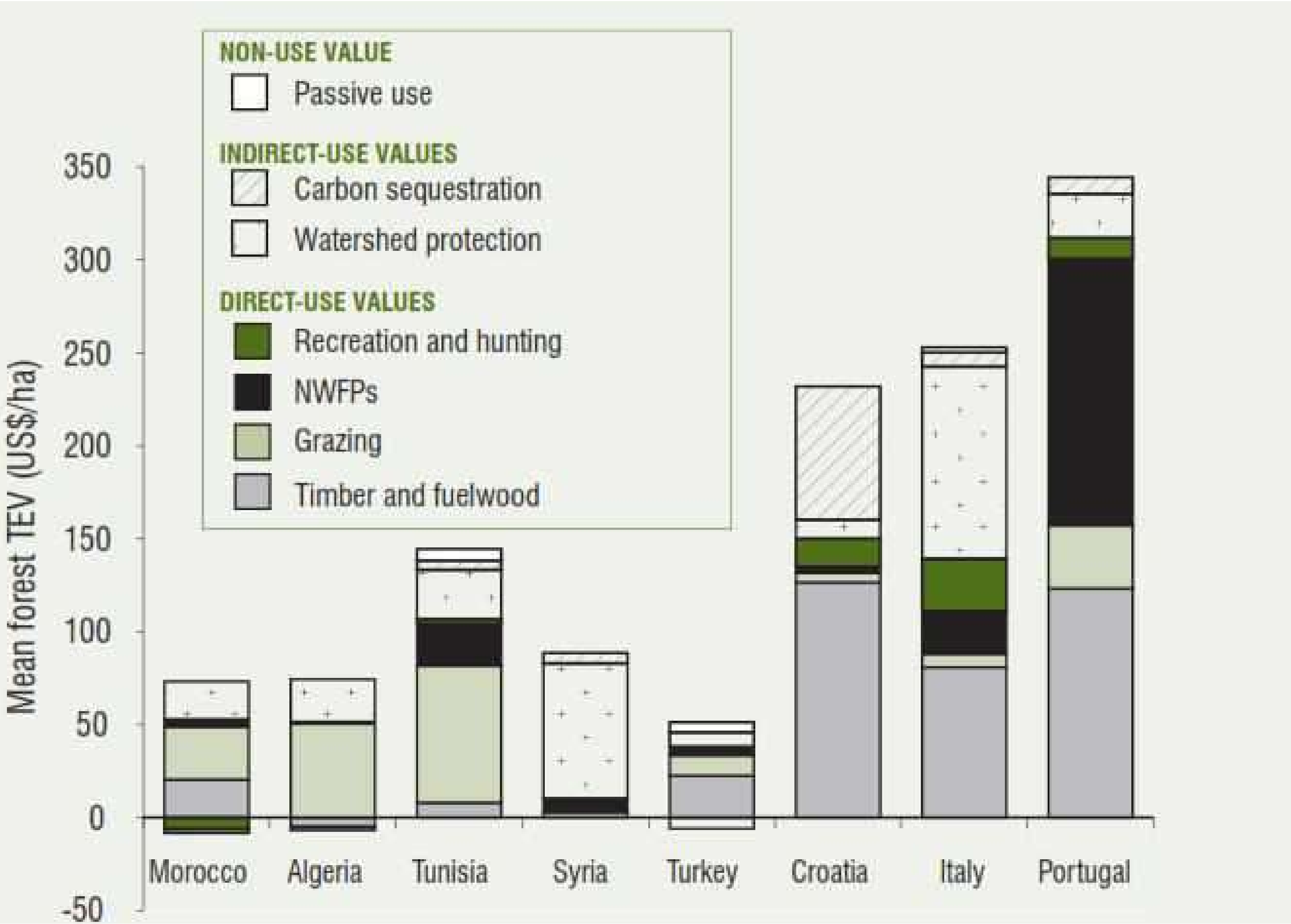
Storm protection - function of mangrove forests which benefits coastal properties and infrastructure

Carbon sequestration which benefits the entire global community by abating climate change.

Option values: preserving the option to use in the future ecosystem goods and services (provisioning, regulating, and cultural services) that may not be used at present ref.

Non-use values: refer to the enjoyment people may experience simply by knowing that a resource exists This kind of value is usually known as existence value (or, sometimes, passive use value) ref.

Benefits from forests in Mediterranean countries



Source: https://www.cbd.int/doc/case-studies/inc/cs-inc-iucn-nc-wb-en.pdf

Human System vs Ecosystem

Anthroposystem

- Very simple ecosystem; max. 3 trophic levels
- Open system; minimal recycling
- High efficiency of transfer of biomass to higher trophic level
- Monoculture; high density
- Few favored species encouraged; weeds destroyed
- Static, highly unstable
- Few people feed the rest-agriculture

Ecosystem

- Often highly complex food webs
- Often closed systems with significant recycling
- Low efficiency of transfer of biomass to higher trophic level
- High biodiversity
- Natural balance in species populations achieved adapted to conditions
- Robust, stable, dynamic, adaptable, evolving

Problems with Human Systems

- Dependent on very few species
  - 80% of world food from 15 species.
  - Human consume only 150 out of the estimated 50,000 edibles.
  - Out of 10,000 cereals, not one new has been cultivated in the past 2000 yrs.
- Inherently unstable
  - Irish Great potato famine (1845-47) wind-borne potato blight fungus; near total crop failure
  - 1 million dead due to starvation, typhoid and cholera
- Require constant inputs; pesticides, fertilizers, etc.
- Prone to pest attacks and failures
- Pollute soil, air, water
- Soil degradation and topsoil loss

Threats to Ecosystems

ref

- Habitat Destruction
- Pollution
- Eutrophication
- Invasive species
- Overharvesting
- UV Radiation

Ecosystems Conservation

ref

- Establishment of protected areas
- Rules that prohibit farming on sloping land or the use of pesticides
- Adopt more environmentally friendly land uses
- Discouraging them from adopting more harmful

Thank You

Extra Slides

Unit 4: Major Environmental Issues

Global Climate Change

Summary

Introduction-some facts

Historical climate data

Global Temperature Models

The Greenhouse effect

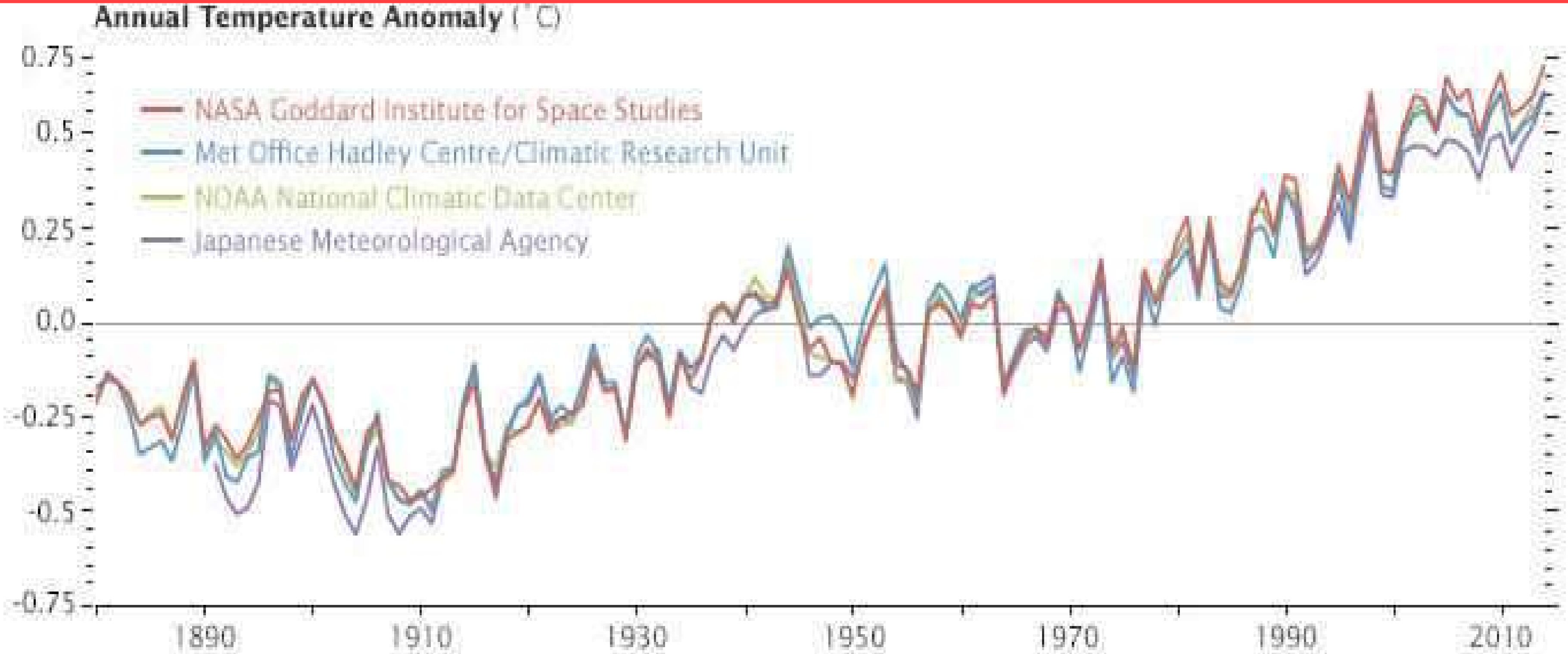
Global warming

Climate Change initiatives

Case studies- Climate Change

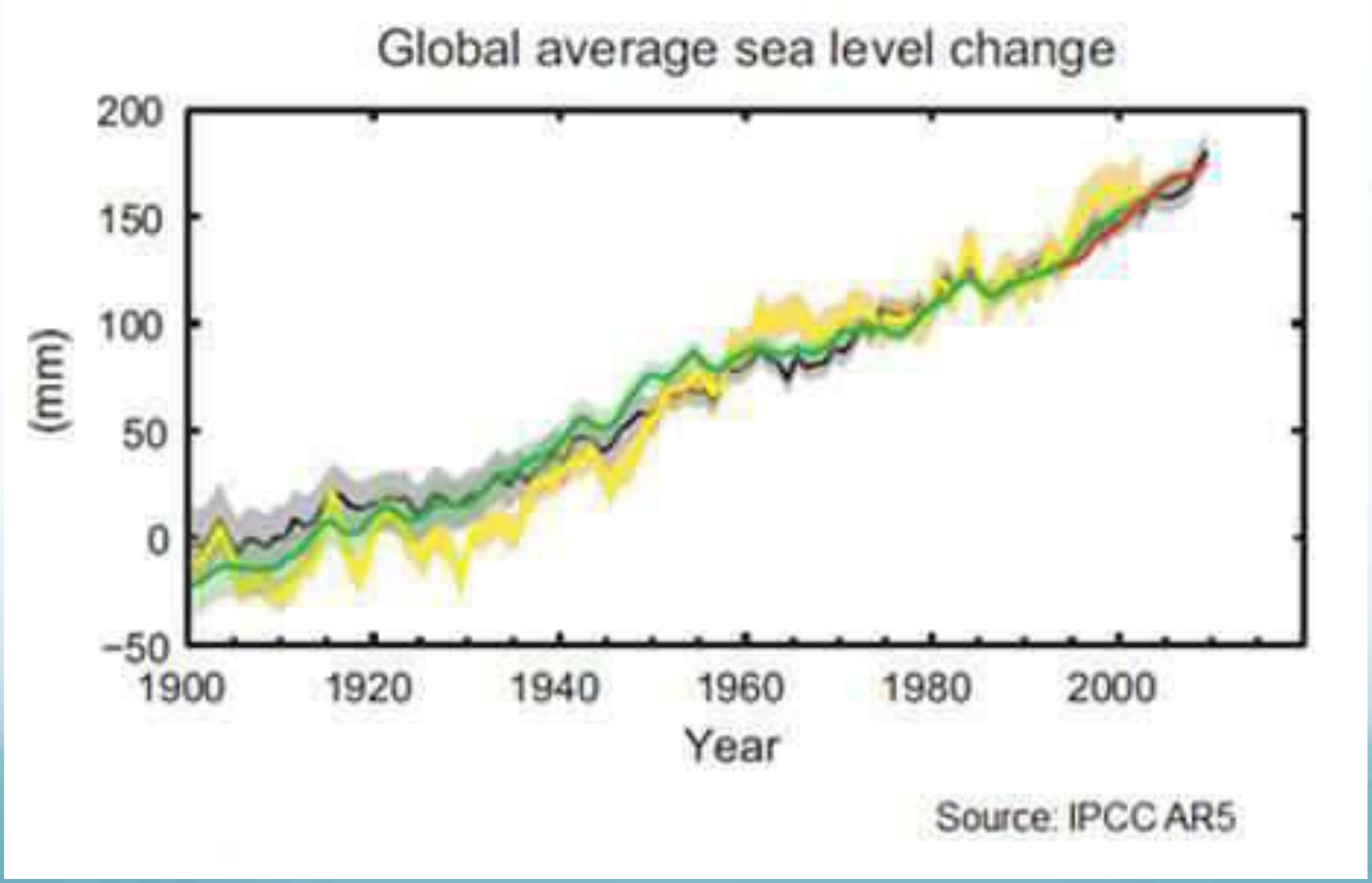
Some Facts…

The global average surface temperature has increased over the 20th century by about 0.6°C (IPCC).



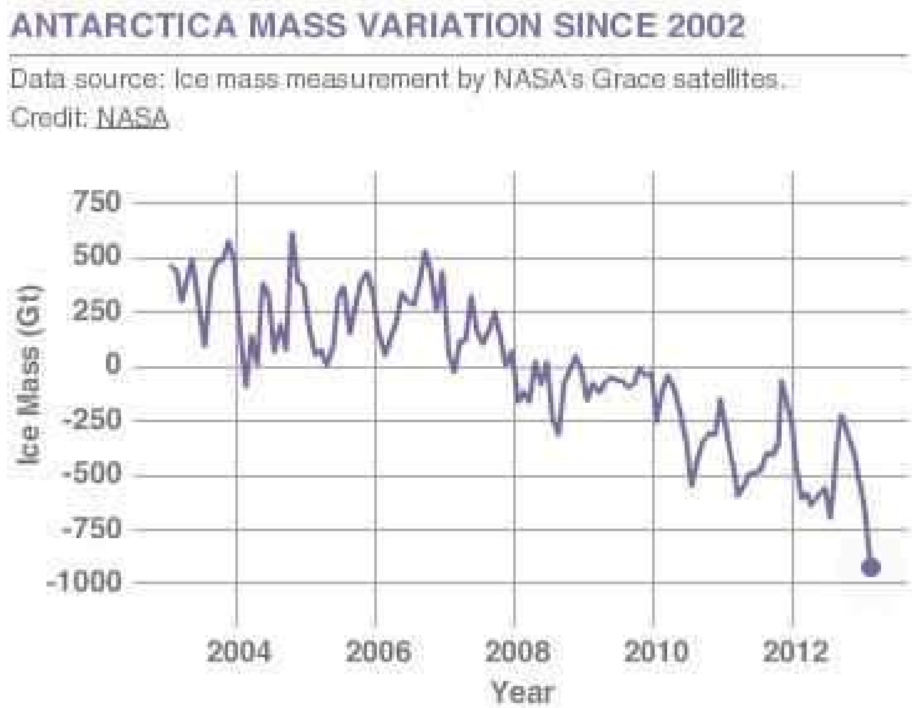
Some Facts…

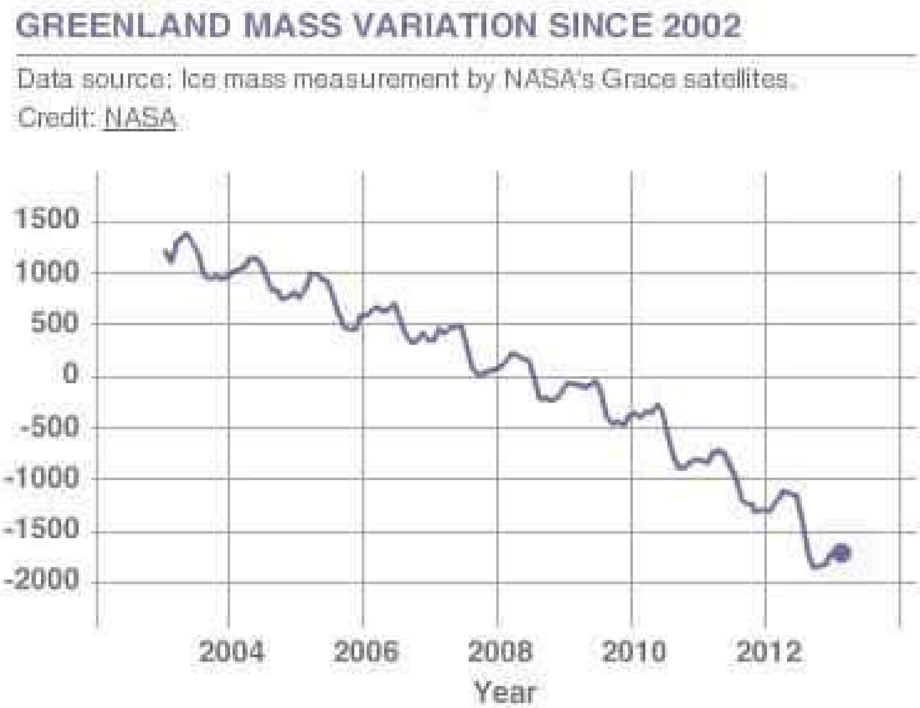
The global average sea level rose by 0.19 m (IPCC)



Some Facts…

There is a significant reduction in glacial mass in poles.





Note: In the above charts, mass change is relative to the average during the entire period. (Reference)

An iceberg of the size of the state of Delaware split off from Antarctica's Larsen C ice shelf- NASA reported on 12 July 2017

Who updates the climate information?

- **Meteorological stations (local scale)**

  Tamil Nadu Agriculture University (TNAU)

- **Satellite images**
- **Global agencies**

IPCC (Intergovernmental Panel on Climate Change)

NASA (National Aeronautics and Space Administration)

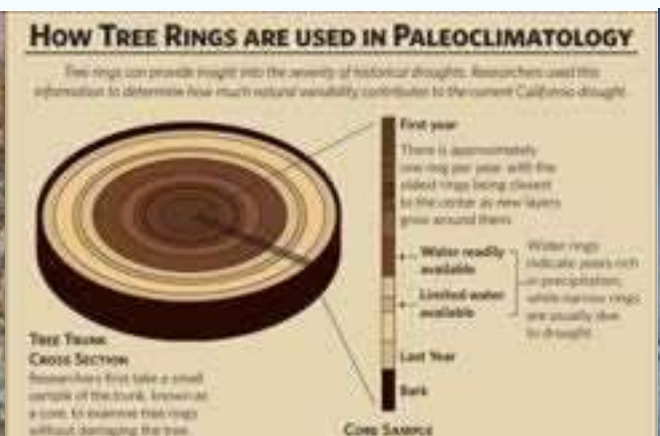
JMA (Japan Meteorological Agency)

IMD (India Meteorological Department)

Historical climate data

Climatologists collect historical temperature data using different methods:

- Tree rings
- Changes in ice volume and sea level
- Fossil pollen analysis
- Glacial movements



Historical climate data…

- One of the most fruitful approaches to record global temperatures involves an observed correlation between the world's ice cover and concentration of the isotope O^{18} in seafloor sediments.
- When water evaporates from the oceans it contains a mix of two isotopes O^{16} and O^{18}.
- O^{18} being heavier, water vapor containing O^{18} condenses and falls as precipitation somewhat sooner than water vapor containing O^{16}.
- Thus Precipitation over ocean tends to be slightly richer in O^{18} than precipitation that must travel further to reach polar ice sheets.
- Precipitation that forms glaciers and ice sheets are relatively depleted of O^{18}.

Historical climate data

- As the world's ice increases, it selectively removes O^{16} from the H_2O cycle and concentrates the remaining O^{18} in the oceans.
- Due to this marine organisms that build their shells out of calcium carbonate in seawater will have higher ratio of O^{18} to O^{16} in their shells when it is cold and more of the world's water is locked up in the glaciers and ice.
- By dating marine sediments and observing the ratio of the two oxygen isotopes in their carbonates, a historic thermometer can be created.
- By careful analysis of the isotope ratios in the Vostok ice core (a 2083 m long ice core recovered by the Soviets at Vostok in East Antarctica) a continuous 160,000 year temperature record is obtained.

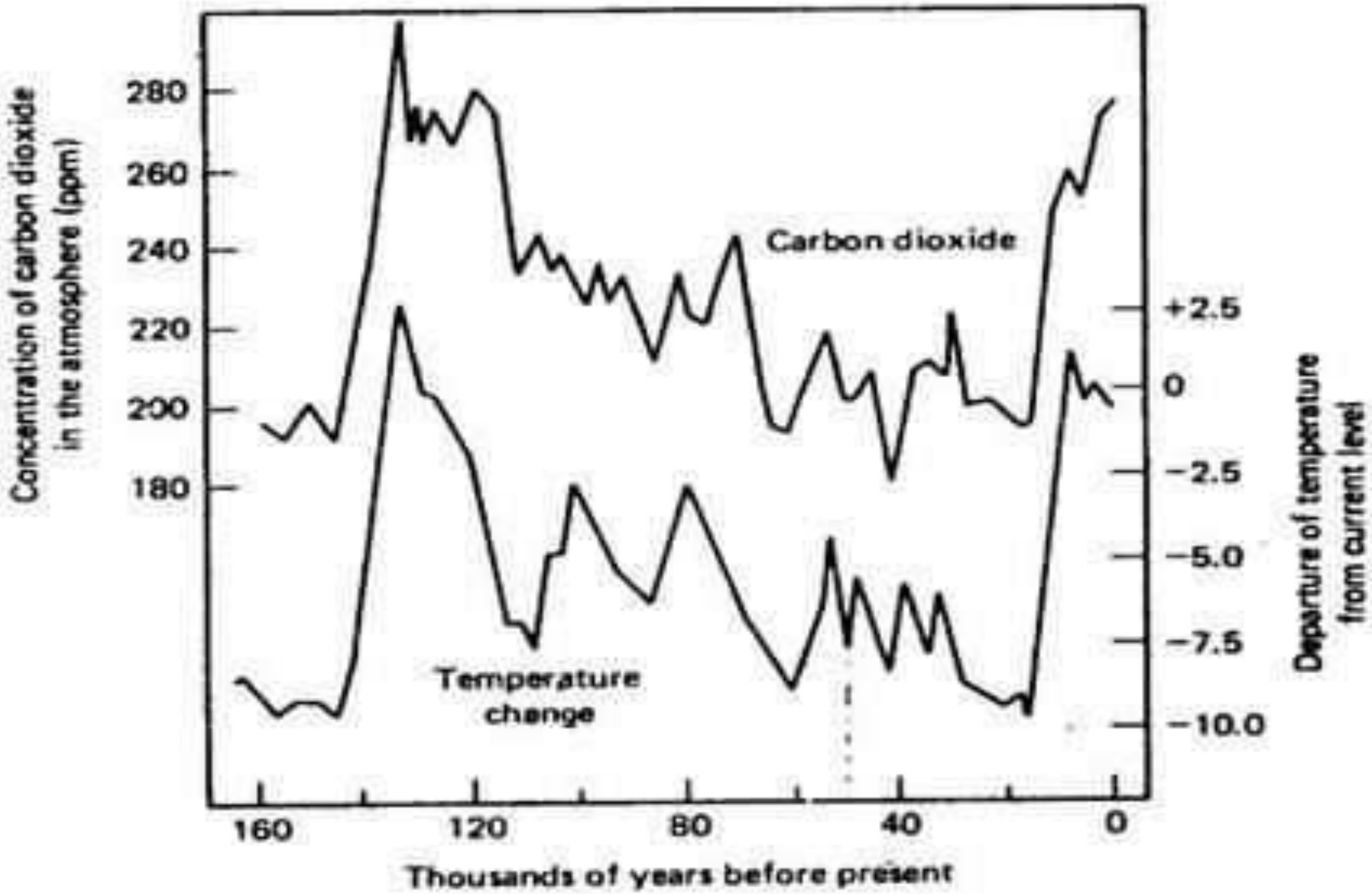
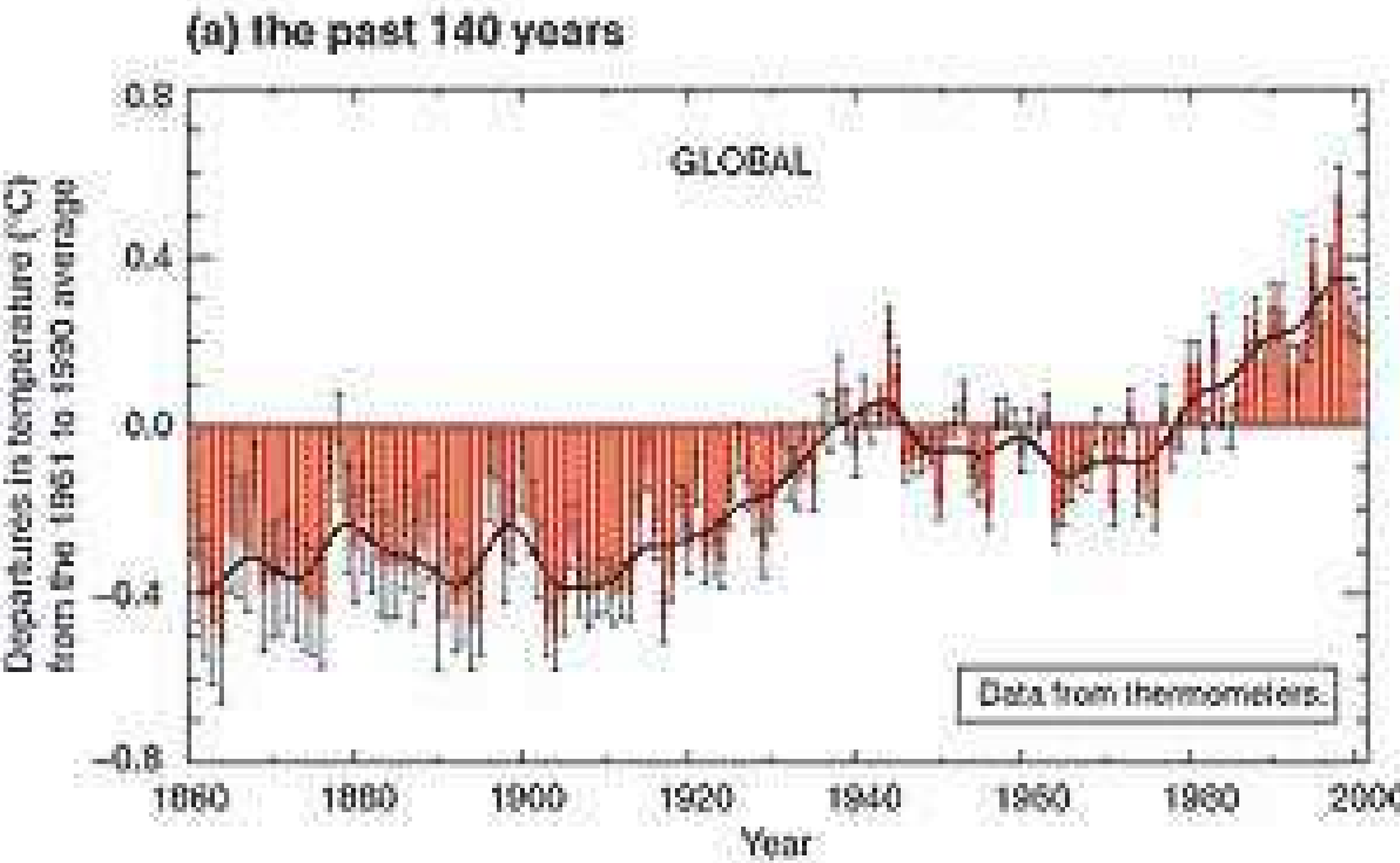


Figure 8.2 CO_2 concentrations (ppm) and Antarctic temperatures (°C) plotted against age in the Vostok record. Temperatures are referenced to current Vostok surface temperature. (*Source:* Barnola et al. Reprinted by permission from *Nature*, vol. 329. Copyright © 1987 Macmillan Magazines Ltd.)

Variations of the Earth's surface temperature for:



Historical climate data..

- Historical record of global temperature shows a primary cycle between glacial episodes of about 100 000 years mixed with a periods of 23 000 years and 41 000 years
- The 100 000 years cycle is accounted with change in shape of earth's orbit from elliptical to circle
- 23 000 year cycle is associated with the precession or wobble of earth's spin axis
- 41 000 years cycle is related to earth's tilt.

Global Temperature Models

- Earth as a Black body
- This model predicts a global average temperature of 279 K (remarkably close to 288 K (15°C), actual global average temperature.
- Unfortunately this is a coincidence.

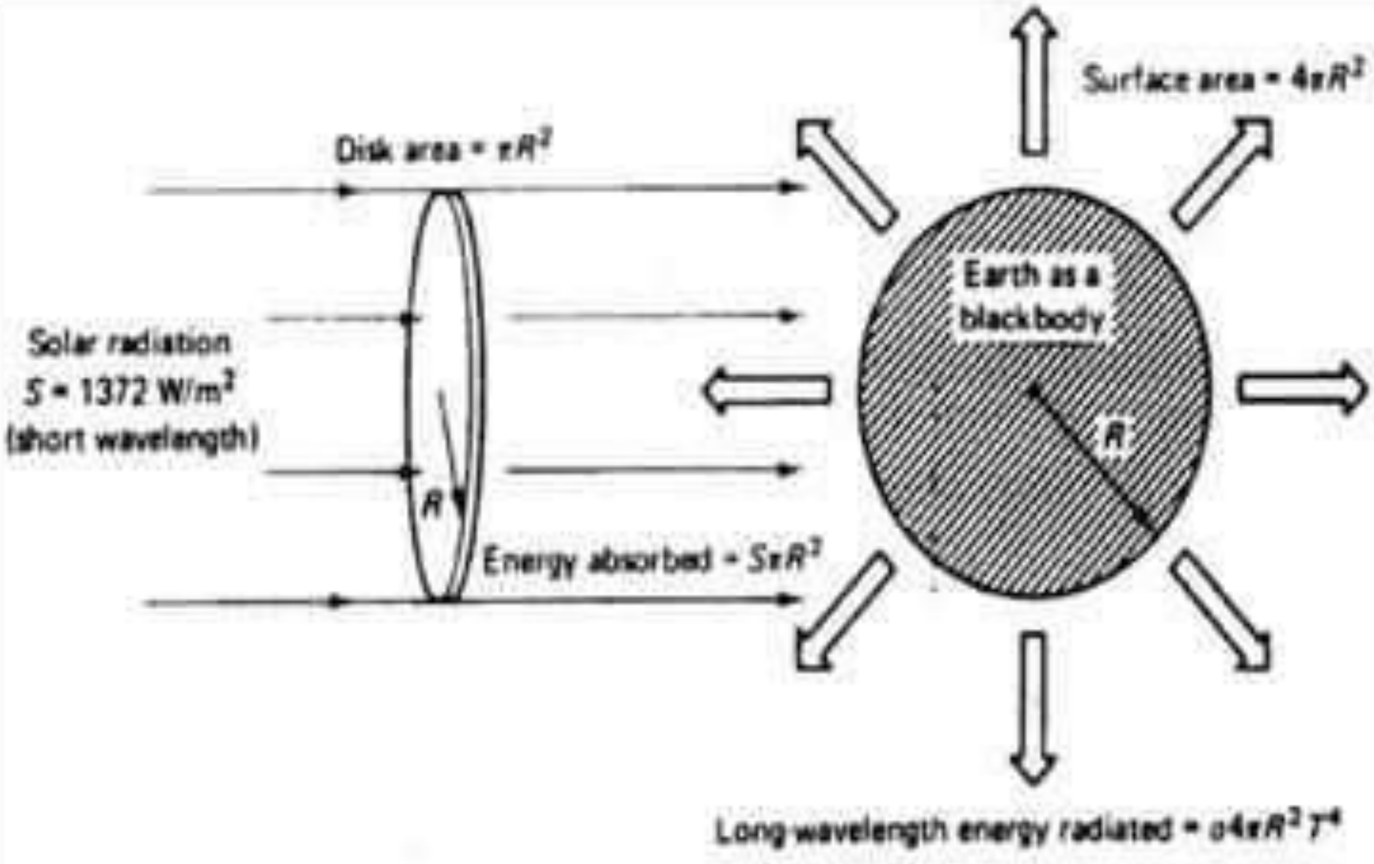


Figure 8.4 In this simplest model, the earth is treated as a blackbody, absorbing all radiation impinging upon it, and radiating an equal amount.

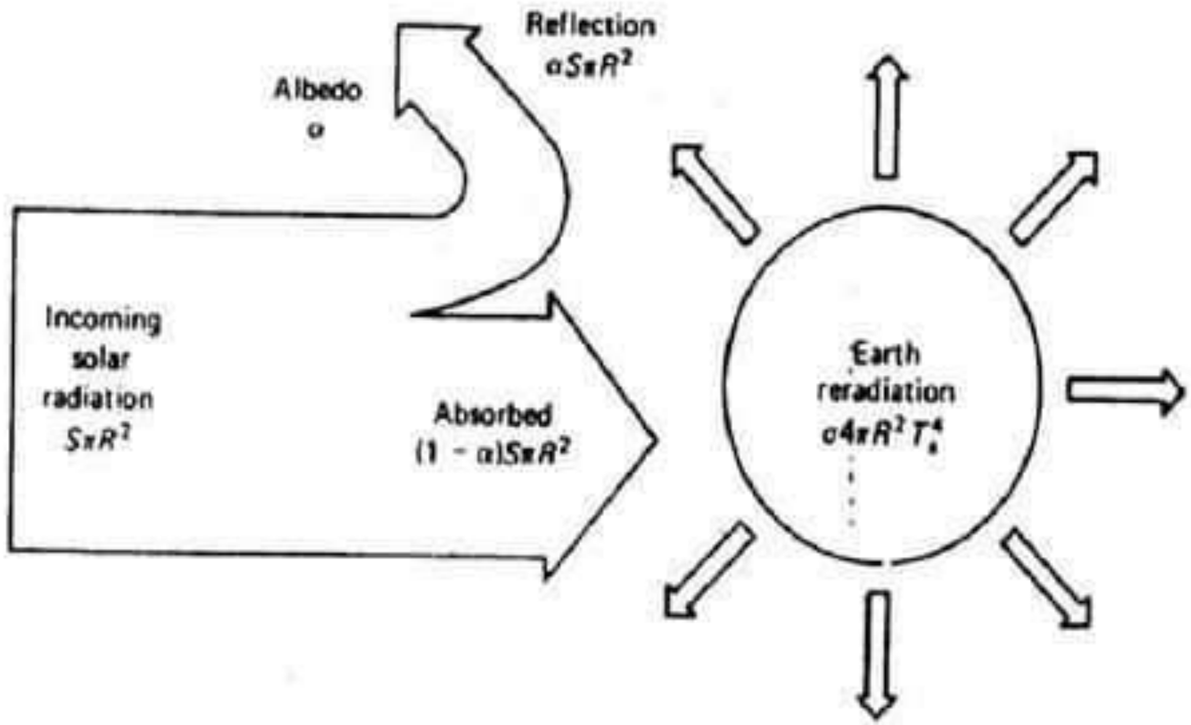


Figure 8.5 A more realistic model that includes the earth's albedo.

Simple radiation balance model that includes Earth’s Albedo

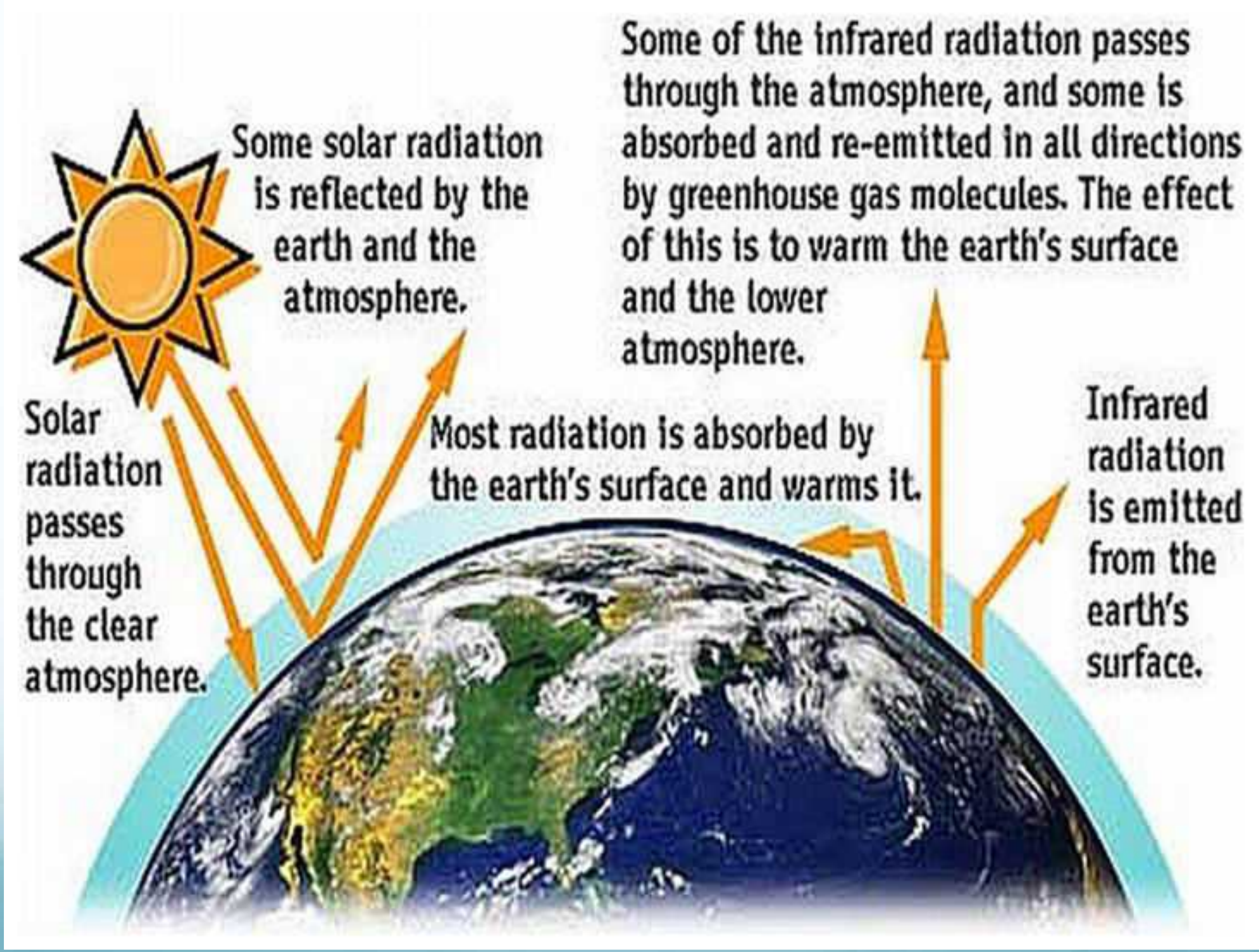
- The fraction of solar radiation that is reflected is known as *albedo (30 % for earth)*

- With this model the global average temperature is 255K! (it has worsened the situation)
    - What’s Wrong?

The Green House Effect

- The surface of earth is 33°C higher than what is predicted.
- Solar energy is ***short wavelength*** *(less than 4 μm)*
- Energy radiated from Earth's surface is ***long wavelength*** *thermal radiation (more than 4 μm)*

Green House Effect



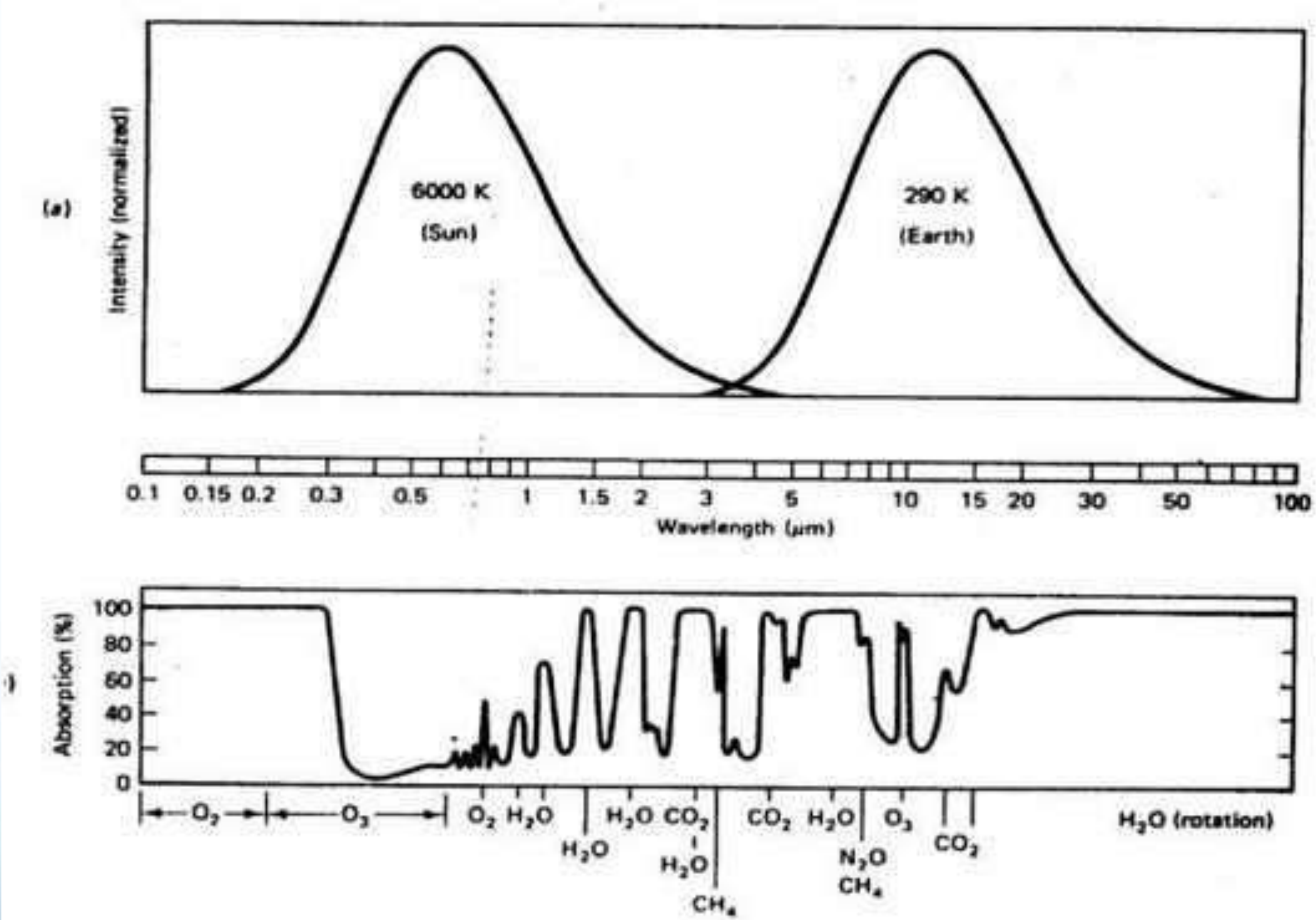


Figure 8.6 (*a*) Normalized blackbody radiation curves for the sun and earth. (*b*) Atmospheric absorption on a clear day. (Adapted from Wallace and Hobbs, 1977.)

Greenhouse effect enhancement and consequences

- Anthropogenic sources of a number of gases are enhancing the green house effect resulting in Global Warming
- Calculations indicate that a rise in sea level of about ¼ m per degree Celsius.
- A total rise of 1-3 m is projected by the end of next century.

Carbon dioxide

- Global temperature is found to have close relation with presence of carbon dioxide in the atmosphere.
- 1 ppm of CO_2 = 2.12 giga ton CO_2
- At the beginning of 19^{th} century the concentration of carbon dioxide was around of 280 ppm.
- Present value of carbon dioxide is around 324 ppm.
- If an exponential growth is modeled, the carbon dioxide level will be 560 ppm by 2100!!

Worlds Changing Scenario

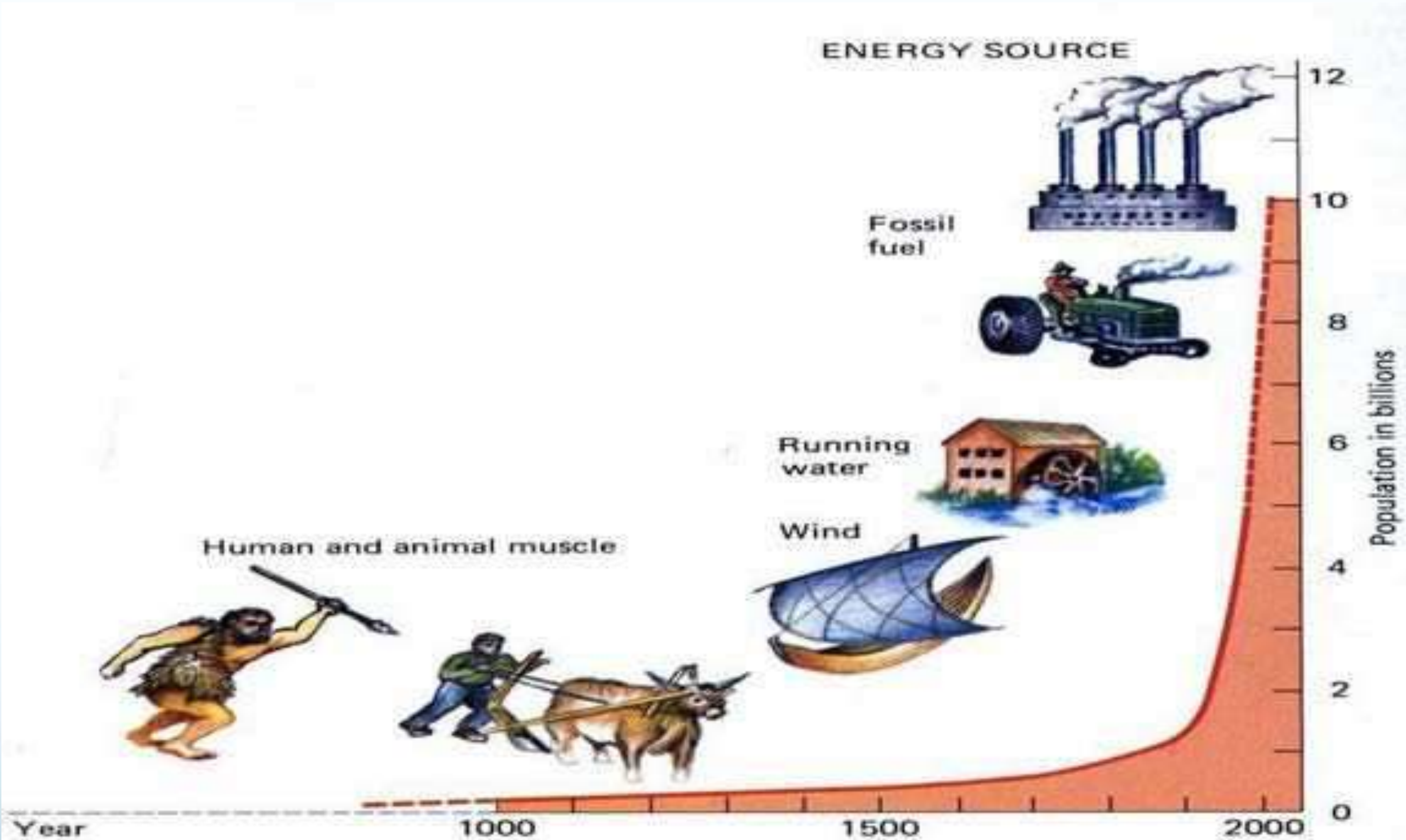


Table 8.3 summarizes some of the characteristics of these gases, including the relative greenhouse efficiency of each compared with carbon dioxide. A molecule of CFC, for example, exerts approximately 15 000 times the greenhouse warming effect as a molecule of CO_2. Table 8.3 also points out the relative global

TABLE 8.3 MAJOR GREENHOUSE GASES AND THEIR CHARACTERISTICS

Gas	Atmospheric concentration (ppm)	Annual concentration increase (%)	Relative greenhouse efficiency (CO_2 = 1)	Current greenhouse contribution (%)	Principal sources of gas
Carbon dioxide	351	0.4	1	57	Fossil fuels, deforestation
CFCs	0.00225	5	15 000	25	Foams, aerosols, refrigerants, solvents
Methane	1.675	1	25	12	Wetlands, rice, livestock, fossil fuels
Nitrous oxide	0.31	0.2	230	6	Fuels, fertilizer, deforestation

Source: Flavin (1989).

Are human activities modifying the atmosphere?

- The atmospheric concentration of carbon dioxide (CO_2) has increased by 31% since 1750 .
- "The atmospheric concentration of methane (CH_4) has increased by 151% since 1750 and continues to increase
- The atmospheric concentration of nitrous oxide (N_2O) has increased by 17% since 1750 and continues to increase.
- Snow cover and ice extent have decreased by about 10% when compared to 1960.

Chlorofluorocarbons

- These are molecules that contain chlorine, fluorine and carbon
- Their presence in the atmosphere is entirely due to human activities.
- These molecules are inert and non water soluble, so they are not destroyed through chemical reactions or removed with precipitation.

Global warming and Ozone – Depletion impacts of CFCs

- Fully halogenated CFCs have long atmospheric lifetimes,contain relatively large amounts of chlorine, and can absorb strongly within the 7 to 13 μm atmospheric window
- Therefore, they have considerable potential for global warming and ozone depletion.
- They are 15000 times potent than carbon dioxide

Other Greenhouse Gases

1. Methane

- Naturally occurring
- Increasing due to human activities
- Significant increase due to food-growing activities, cattle production
- It is also released during production, transportation and consumption of fossil fuels
- It absorbs at about 7.66 micrometer and 25 times as potent as carbon dioxide in global warming.

Other Greenhouse Gases

2. Ozone

- About 90% of Ozone resides in the stratosphere
- It protects us from UV radiations
- Increase in the Troposphere ozone can contribute to raising global temperature

Other Greenhouse Gases

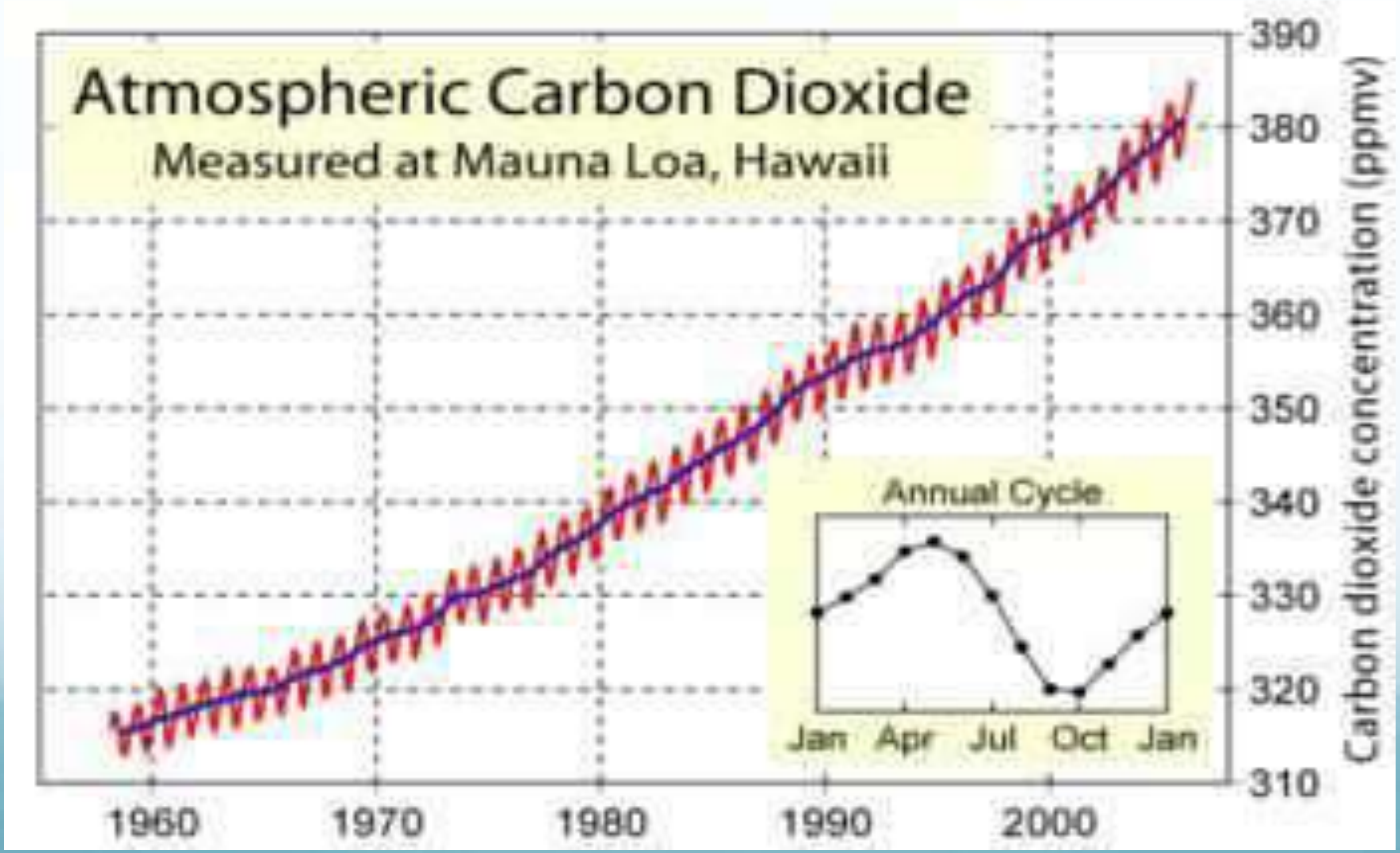
3. Nitrous Oxide

- Released into the atmosphere mostly during the nitrification portion of the nitrogen cycle.
- Combustion of fossil fuels and nitrogen fertilizer are the two major human activities that release this to the atmosphere
- It has strong absorption bands at 4,5,7,8 and 17 micrometer and it is about 280 times potent as carbon dioxide in causing global warming.

Global warming

- Increase in carbon dioxide emissions

The Keeling Graph



IPCC 2014 Reports:

"Warming of the climate system is unequivocal. It is extremely likely that human influence has been the dominant cause of observed warming since 1950".

"*…the longer we wait to reduce our emissions, the more expensive it will become"*.

GLOBAL WARMING

- Impact of high use of energy
- Worldwide repercussions
  - Natural hazards
  - Droughts and floods
  - Sea-level rise
  - Spread of infectious diseases

Is global warming occurring?

GREENLAND ICE SHEET MELT EXTENT

WORLD SCIENTISTS' WARNING TO HUMANITY (1992)

1670 distinguished scientists (including 104 Nobel Laureates) said:

"Human Beings and the natural world are on a collision course"

"We must move away from fossil fuels to cut greenhouse gas emissions"

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

- Set up in 1988 by World Meteorological Organization (WMO) to assess the science related to climate change
- Currently has 195 member countries
- IPCC provides scientific and intergovernmental based outlook to develop climate related policies

See also: http://www.ipcc.ch/

IPCC REPORT

Authors are eminent scientists from all over the globe grouped into 3 working group (WG)

WG-1: Physical Science Basis

WG-2:Impacts, Adaptation and Vulnerability, and

WG-3: Mitigation of Climate Change & the Task Force on National Greenhouse Gas Inventories (TFI)

United Nations Framework Convention on Climate Change

UNFCCC is one of the ramifications of the Rio Earth Summit 1992, started its function in 1994

Currently it is having 197 (countries) parties to the convention

The ultimate objective of UNFCCC:

"..stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system…"

Responses to Climate Change

As per UNFCCC, two fundamental response strategies to tackle Climate Change

Adaptation:

“refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”.

Mitigation:

“refers to implementing policies to reduce GHG emissions and enhance sinks and technological change and substitution that reduce resource inputs and emissions”.

THE KYOTO PACT

- Kyoto Pact is an UNFCCC agreement commits its Parties by CO_2 emission reduction targets
- Came into force on 16.2.2005
- First commitment period 2008-2012

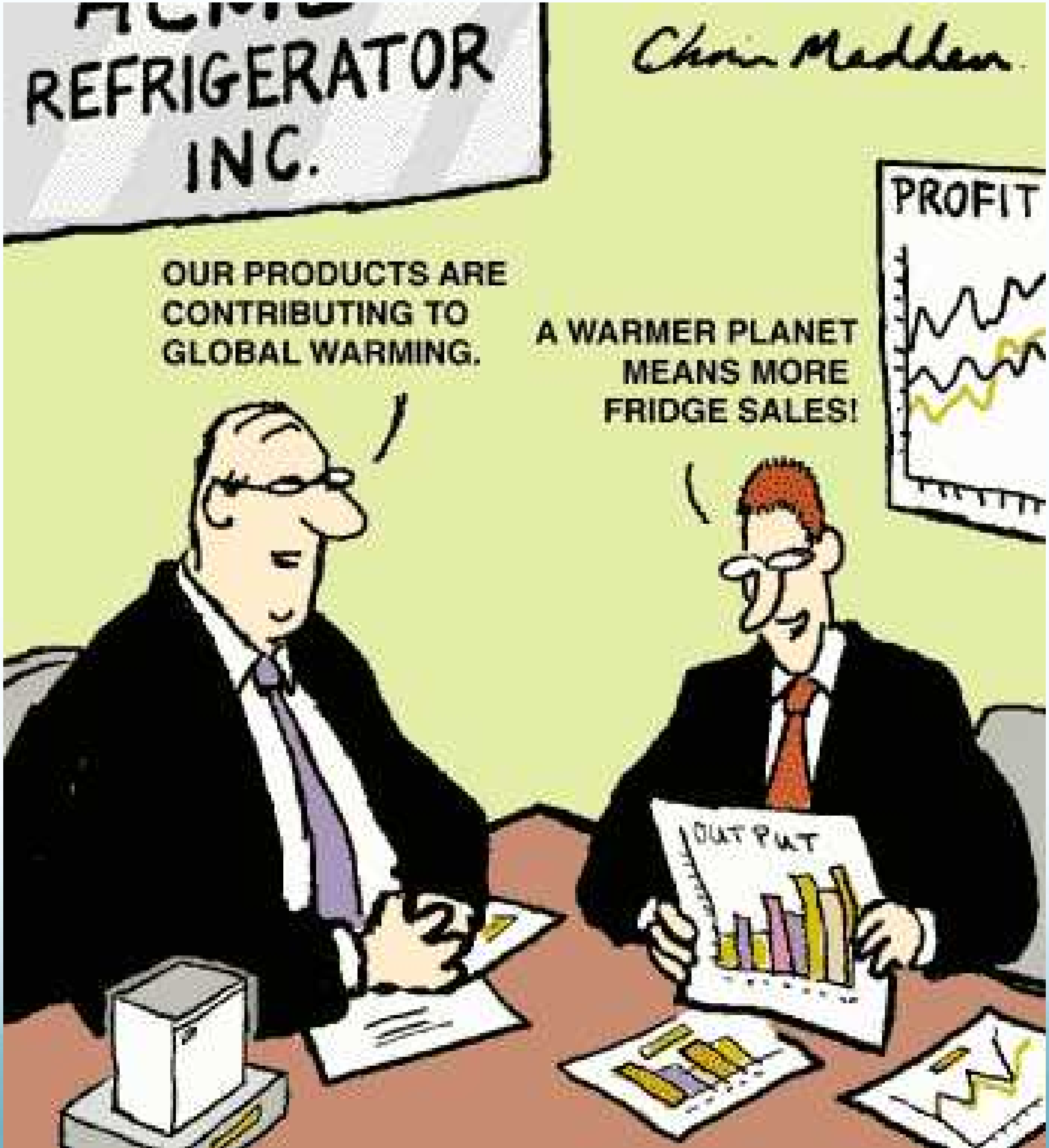
CO_2 emission reduction Target→5% in industrial nations 7% in US, below 1990 levels

- Second commitment period January 2013 to 31 December 2020

Target: GHG emissions by at least 18% below 1990 levels

PARIS PACT

- UNFCC conference of parties (COP 21) held in Paris 2015
- Aim is to strengthen the global response to the threat of climate change
- Reaffirms the goal of keeping average warming below 2 degrees Celsius, also urging parties (highly vulnerable developing countries) to “pursue efforts” to limit it to 1.5 degrees
- “Prepare, communicate and maintain” a NDC (Nationally Determined Contributions) by parties


REFRIGERATOR
INC.
Chris Madden
PROFIT
OUR PRODUCTS ARE CONTRIBUTING TO GLOBAL WARMING.
A WARMER PLANET MEANS MORE FRIDGE SALES!
OUTPUT

Impacts of Climate change and global warming

Climate change could kill up to 180 million people in Africa

150,000 people already die every year from climate change
Source: World Health Organisation
100 million more people will be flooded by end of century
30 million more people may be hungry because of climate change by 2050
Source: The Hadley Centre

Rising sea levels and crop failures could create 150 million refugees by 2100

Impacts of Climate change and global warming

Warmer land and waters and rising sea levels are detrimental to sensitive ecosystems

The rate of sea level rise over the Bay of Bengal is at the rate 0.75–6 mm/year (IITM, Pune 2016)

Many unique habitat in India under threat Eg: Sundarbans, world's largest mangrove forest, that abode Bengal tigers and many faunal sps.

Impacts of Climate change and global warming

Mass death of coral reefs because of coral bleaching widely reported in the recent past across the world is attributed to Global warming .

The research have noted that 1700 plants, animals and insects species moved pole wards at an average rate about 4 miles per decade in the last half of the 20th Century.

Over the past 25 years, penguin populations have shrunk by 33 percent in parts of Antarctica, due to declines in winter sea-ice habitat.

Impacts of Climate change and global warming

According to a new global study 90 percent of all large fishes have disappeared from the world's oceans in the past half century.

The golden toad (*Bufo periglenes*) of Costa Rica has disappeared as a direct result of global warming.

Oil from wells unable to meet demand, massive disruptions in transportation & economy, not enough time to switch to renewables

Climate Change and Global Warming - India

-Unpredictability in monsoon rains, which India’s agriculture is heavily dependent on

-Temperature rise of between 2 and 3.5 degrees centigrade, would cost India a loss of between 9 and 25 percent of total agricultural revenue

-Melting glaciers will affect one-sixth of the world's population residing mainly in the Indian subcontinent.

Climate Change impacts-
Case Studies

Tuvalu Islands

- Chain of nine coral islands in the South Pacific
- Small, remote islands between Hawaii and Australia.
- Area of 25 sq km and a population of 11,000
- Paradise with chalk-white beaches and coconut palms.

The problem:

- Islands located at low levels.
- Most houses are just three metres above sea level.

Tuvalu: First victim of global warming?

- Sea level rise already a fact
- Salt water flowing up through porous fossil ground
- Traditional root crop, Pulaka, affected
- Tides are higher and the storms are more frequent and severe
- Crops and plantations are being destroyed by salt water
- People migrating to New Zealand,
- Tuvalu plans to file a case against industrialized countries in International Court of Justice.


Who doesn’t want a house with
a swimming pool? How about a
house *IN* a swimming pool?

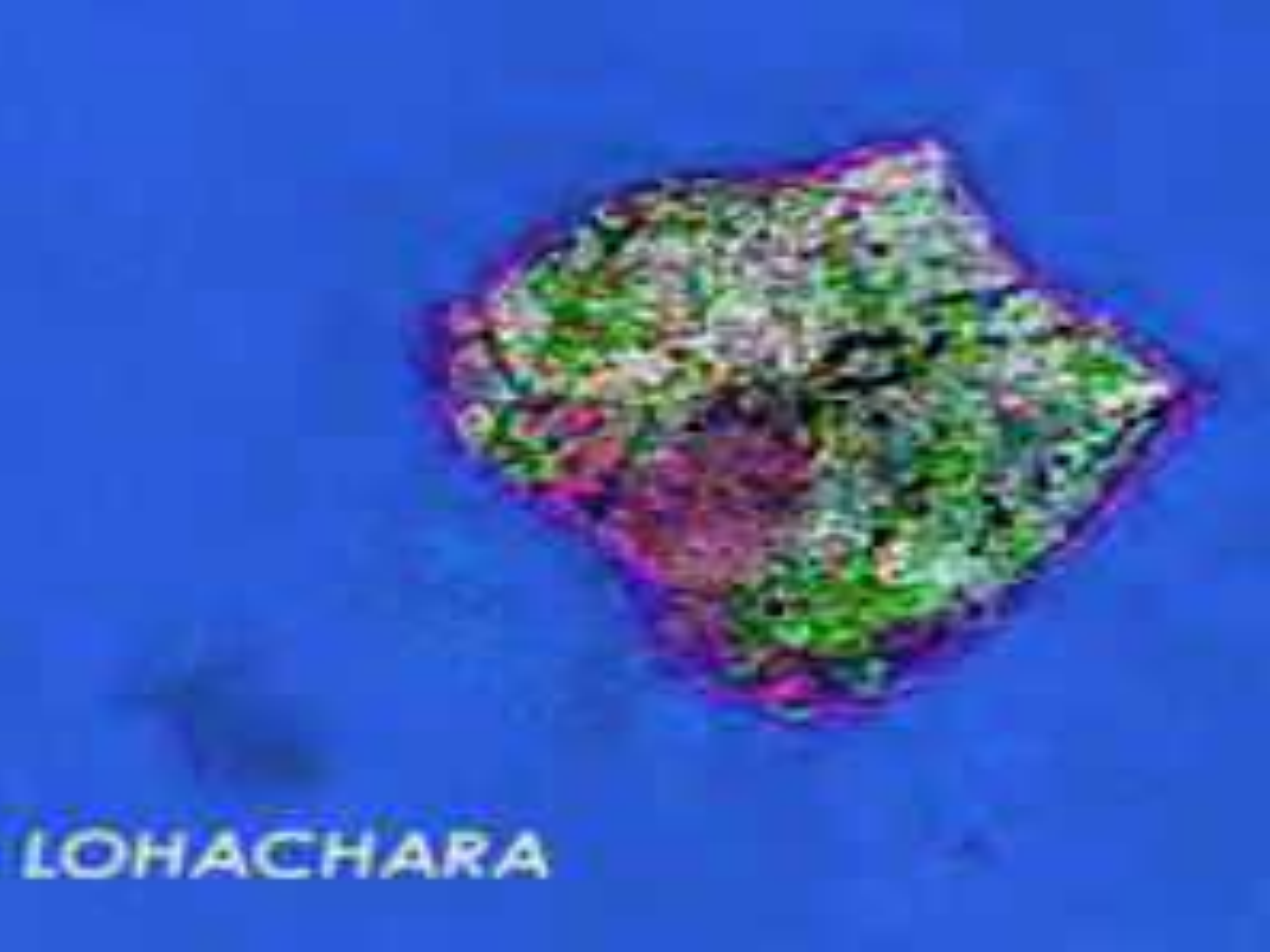
Tuvalu is far away.

We are still safe.

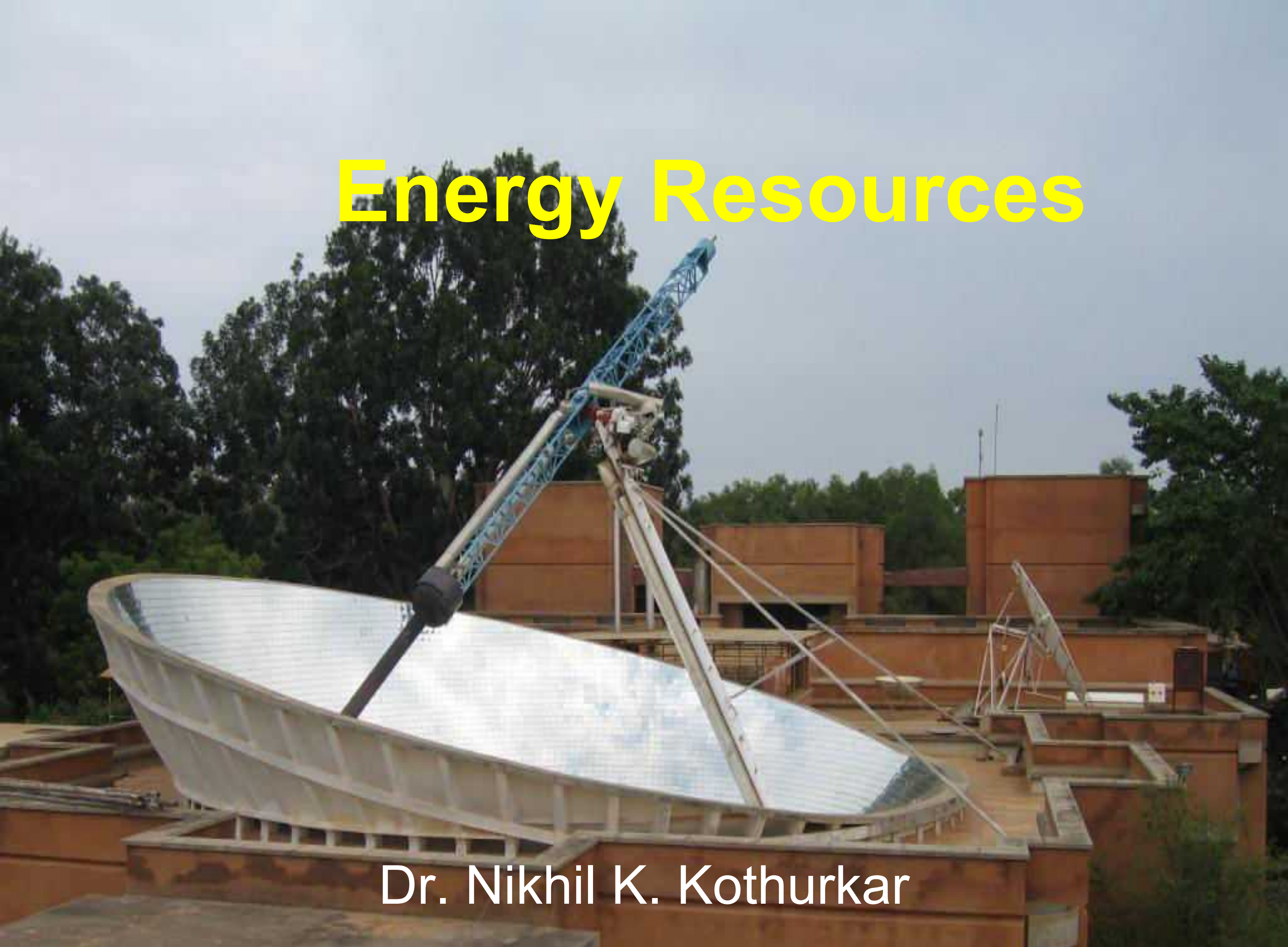
It will not happen everywhere.

Is it true ?

Lohachara Char, India
Image © 2008 TerraMetrics
Google
elev 2 ft Streaming 100%
Eye alt 40057 ft


LOHACHARA

Energy Resources



Dr. Nikhil K. Kothurkar

Outline

- Units and Terms
- Energy Resources, Depletion and Risks
- Environmentally Benign Forms of Energy
- Efficiency Measures
- Reduction in Consumption—Individual Perspective

Energy units

- 1.0 joule (J) = one Newton applied over a distance of one meter (= 1 kg m^2/s^2).
- 1.0 joule = 0.239 calories (cal)
- 1.0 calorie = 4.187 J
- 1.0 gigajoule (GJ) = 10^9 joules = 0.948 million Btu = 239 million calories = 278 kWh
- 1.0 British thermal unit (Btu) = 1055 joules (1.055 kJ)
- 1.0 Quad = One quadrillion Btu (10^{15} Btu) = 1.055 exajoules (EJ), or approximately 172 million barrels of oil equivalent (boe)
- 1000 Btu/lb = 2.33 gigajoules per tonne (GJ/t)
- 1000 Btu/US gallon = 0.279 megajoules per liter (MJ/l)

Power Units

- 1.0 watt = 1.0 joule/second = 3.413 Btu/hr
- 1.0 kilowatt (kW) = 3413 Btu/hr = 1.341 horsepower
- 1.0 kilowatt-hour (kWh) = 3.6 MJ = 3413 Btu
- 1.0 horsepower (hp) = 550 foot-pounds per second = 2545 Btu per hour = 745.7 watts = 0.746 kW

Heating Value of a Fuel

- Energy (heat) released per unit quantity (mass or volume) of a fuel upon combustion is called its heating value.
- The lower heating value (LHV) is calculated with combustion products in the gas phase…more relevant for mobile applications
- The higher heating value (HHV) is calculated after condensing the gaseous products (mostly water)...more relevant for stationary applications
- Energy contents are expressed here as Lower Heating Value (LHV) unless otherwise stated (this is closest to the actual energy yield in most cases).
- HHV> LHV by….depending mainly on the hydrogen content of the fuel.
  - 5% (in the case of coal), 10% (for natural gas), 6-7% for biomass feedstocks

Fossil Fuels Units and Energy Content

- 1 Petroleum barrel = 42 U.S. gallons = 35 Imperial gallons = 159 L.
- **Barrel of oil** equivalent (boe) = ~ 6.1 GJ = 5.8 million Btu = 1,700 kWh.
- 7.2 barrels oil are equivalent to 1 metric tonne of oil = 42-45 GJ.
  - gasoline density (average) = 0.73 g/ml (= metric tonnes/m^3)
- Note that the energy content (heating value) of petroleum products per unit mass is fairly constant, but their density differs significantly – hence the energy content of a liter, gallon, etc. varies between gasoline, diesel, kerosene.

Fossil Fuels Units and Energy Content

- **Gasoline:**
  - LHV = LHV115,000 Btu/US gallon = 121 MJ = 32 MJ/liter.
  - HHV= 125,000 Btu/US gallon = 132 MJ/gallon = 35 MJ/liter
  - 1 Metric tonne gasoline = 8.53 barrels = 1356 liter = 43.5 GJ/t (LHV); 47.3 GJ/t (HHV)
- **Petro-diesel**
  - Heating Value: 130,500 Btu/gallon (36.4 MJ/liter or 42.8 GJ/t)
  - petro-diesel density (average) = 0.84 g/ml (= metric tonnes/m^3)

Fossil Fuels Units and Energy Content

- **Coal**
  - Bituminous/anthracite (common for power plants): 27-30 GJ/metric tonne (11,500-13,000 Btu/lb);
  - Lignite/sub-bituminous: 15-19 GJ/metric tonne (6,500-8,200 Btu/lb)
- **Natural gas:**
  - HHV = 1027 Btu/ft^3 = 38.3 MJ/m^3; LHV = 930 Btu/ft3 = 34.6 MJ/m^3
  - 1 Therm (used for natural gas, methane) = 100,000 Btu (= 105.5 MJ)

Carbon Content of Fuels

- **Coal** (average) = 25.4 metric tonnes C/TJ
  - 1.0 metric tonne **coal** = 746 kg carbon
- **Oil** (average) = 19.9 metric tonnes C / TJ
- 1.0 US gallon **gasoline** (0.833 Imperial gallon, 3.79 liter) = 2.42 kg carbon
- 1.0 US gallon **diesel/fuel oil** (0.833 Imperial gallon, 3.79 liter) = 2.77 kg carbon
- **Natural gas (methane)** = 14.4 metric tonnes C/TJ
- 1.0 cubic meter **natural gas (methane)** = 0.49 kg carbon
- Carbon content of **bioenergy feedstocks:** approx. 50% for woody crops or wood waste; approx. 45% for graminaceous (grass) crops or agricultural residues.

Outline

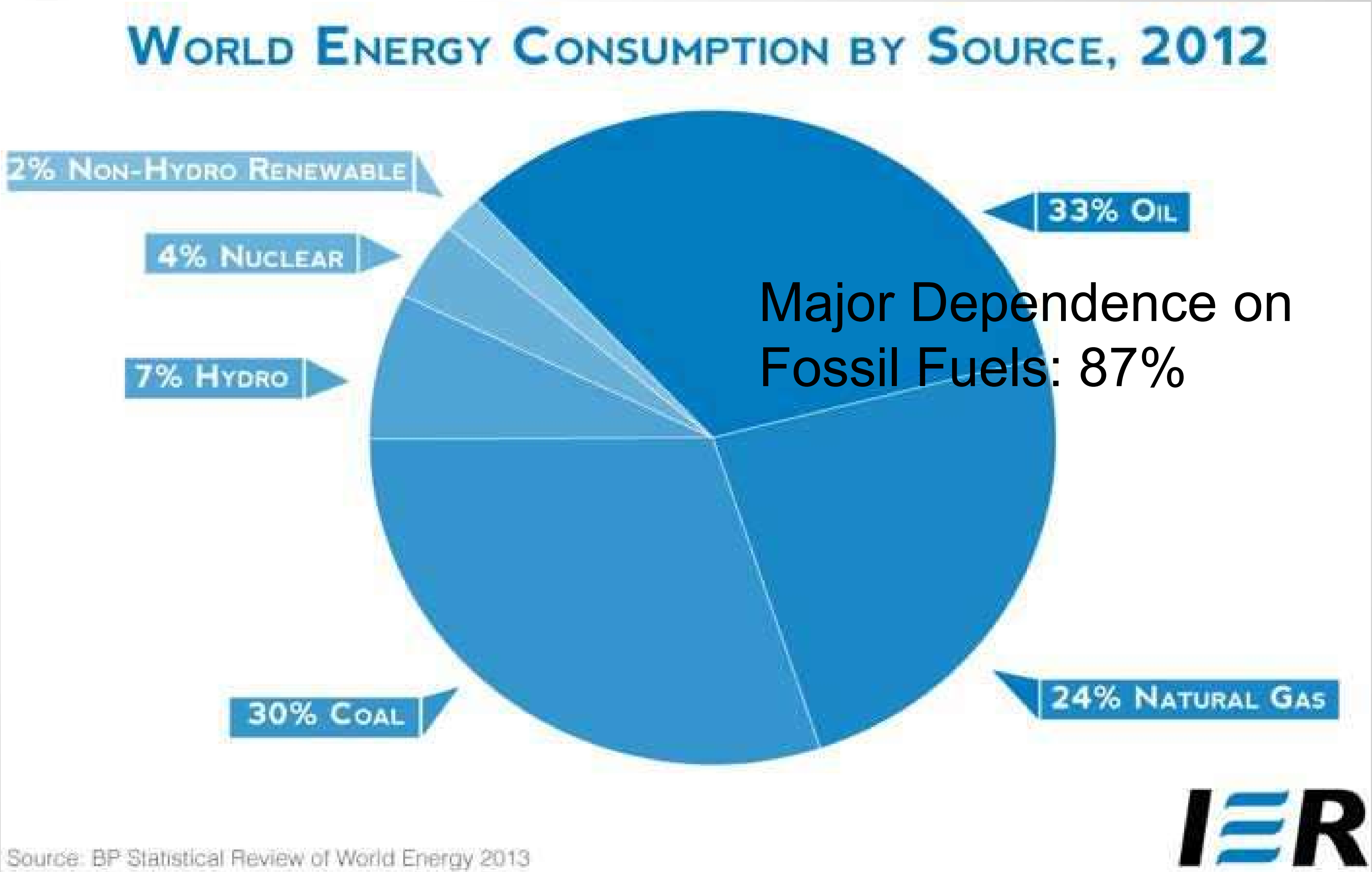
- Units and Terms
- Energy Resources, Depletion and Risks
- Environmentally Benign Forms of Energy
- Efficiency Measures
- Reduction in Consumption—Individual Perspective

Renewable and Nonrenewable Resources

- **Perpetual/Continuous** resources are those that remain available in the same measure for an indefinitely long time e.g. Solar, Wind, Geothermal, Wave power
- **Renewable resources** can be replenished over fairly short spans of time, such as months, years or decades. E.g. Biomass energy, biofuels, Hydroelectric power generation
- **Nonrenewable resources** take millions of years to form and accumulate, e.g. All fossil fuels like coal, oil, natural gas; uranium, thorium (nuclear fuel)

Why do we have a Global Energy Crisis?

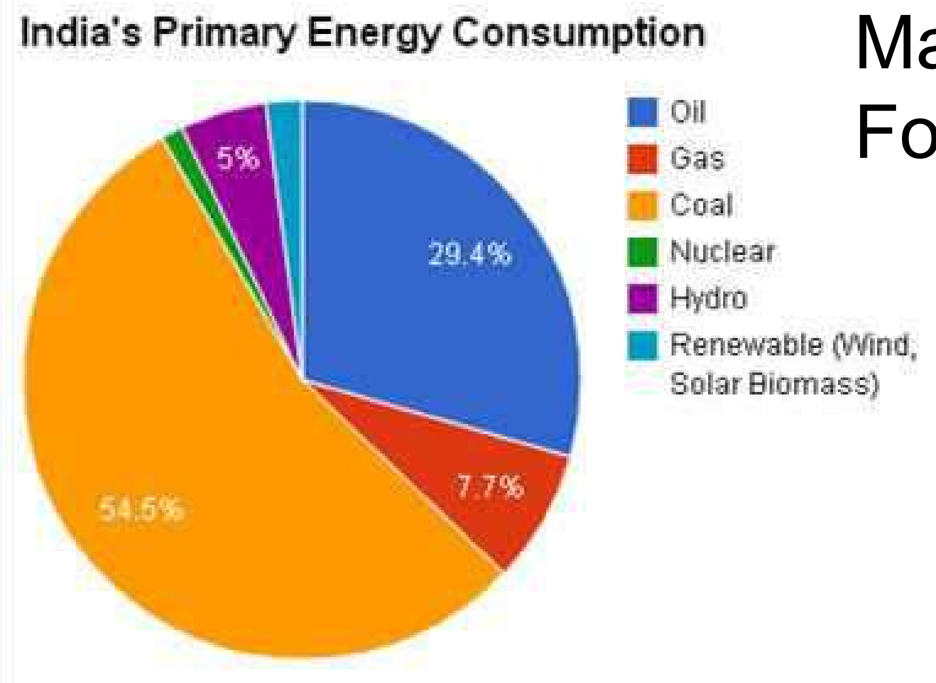
- Humanity has a **near total dependence on fossil fuels** and other ***unsustainable energy sources*** for its needs.
- Hence, energy use causes irreversible damage to Earth's 'life support system'.
  - Consequent global climate change, environmental pollution, health problems...
- The known sources of energy incl. oil, gas, coal and nuclear fuel are exhaustible (some already severely depleted)
- Energy consumption is increasing at an alarming rate—*worsening the social and environmental impacts and accelerating depletion.*
- Shares of most renewable energy forms are presently very low; technological, commercial and policy barriers exist.



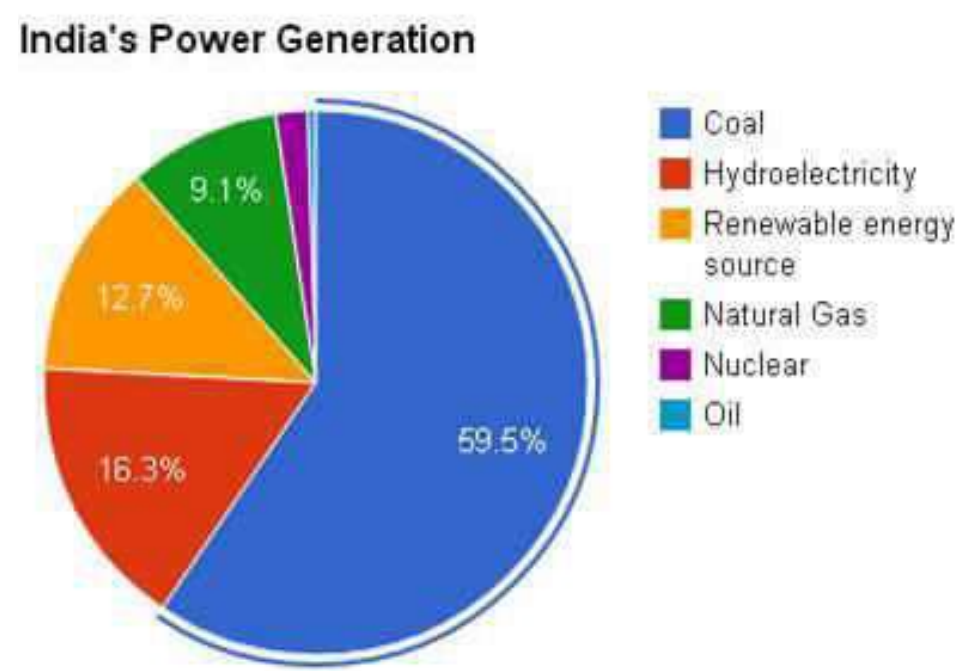
Major Dependence on Fossil Fuels: 87%

http://instituteforenergyresearch.org/analysis/statistical-review-of-world-energy-2013-viva-la-shale-revolucion/

India's Energy Consumption



Major Dependence on Fossil Fuels: 91%



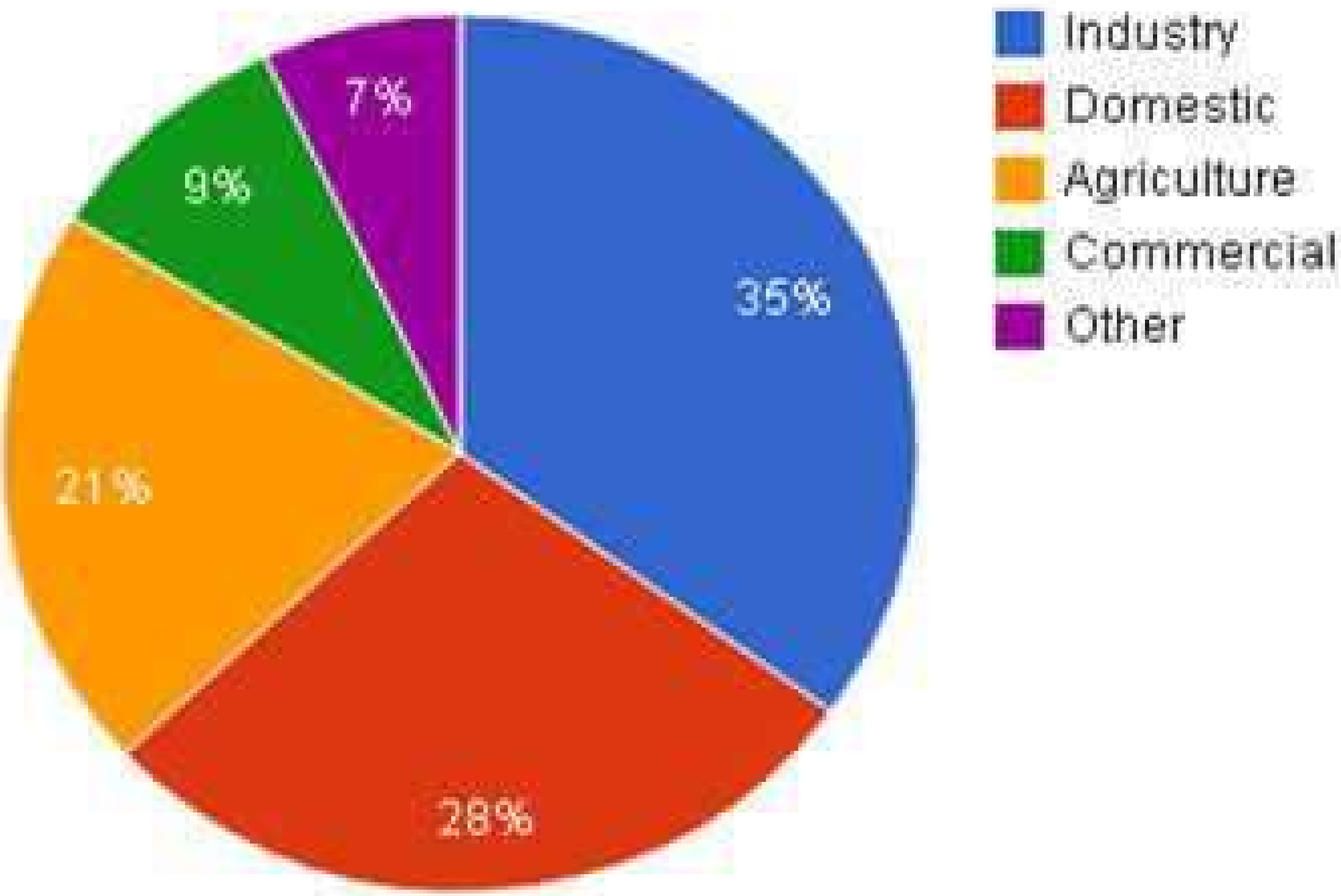
http://en.wikipedia.org/wiki/Energy_policy_of_India#Power_Generation_capacity_in_India

Electricity in India

- Overall electrification rate: 64.5%
  - 35.5% of the population without access to electricity.
- Urban: access to electricity is 93.1% (2008).
- Rural:
  - 80% of Indian villages have an electricity line
  - 52.5% of rural households have access to electricity.

http://en.wikipedia.org/wiki/Electricity_sector_in_India

India's Electricity Use



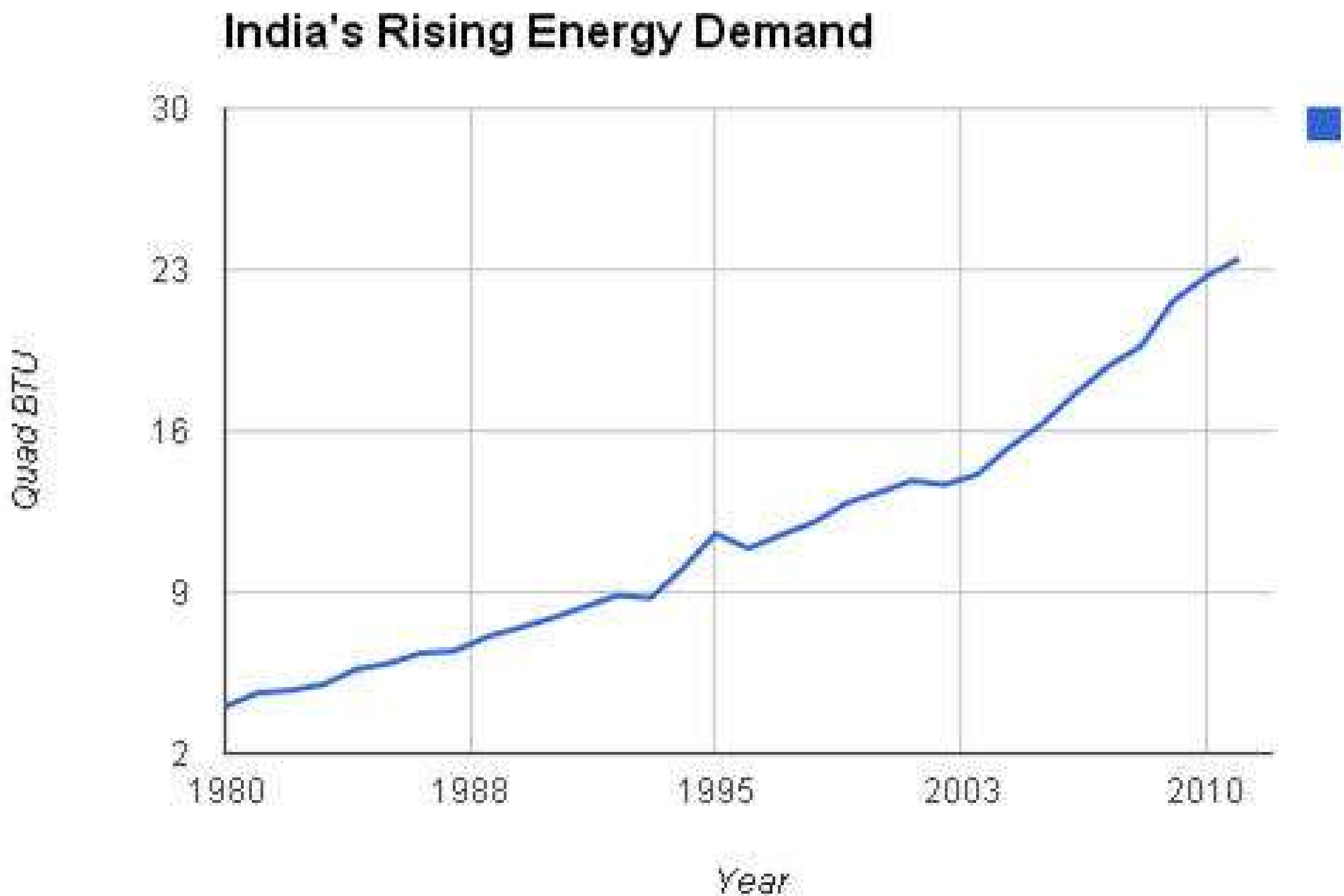
India Electricity Deficit

For 2014–15

- Installed capacity of 258.7 GW (Jan 2014).
- Avg. base load energy deficit = 5.1%
  - 12% in S
  - 17.4% in NE)
- Peaking shortage = 2%
  - 22.2% in S
  - 12% in NE

http://en.wikipedia.org/wiki/Electricity_sector_in_India

Rising Demand



http://www.indexmundi.com/energy.aspx?country=in&product=total-primary-energy&graph=consumption

Depleting Sources

- Fossil Fuels (oil, coal, gas):
  - Non-renewable.
  - Oil depleting rapidly. Peak oil
  - Coal: Mining is leading to deforestation and habitat loss.
- Nuclear:
  - Uranium depleting rapidly
  - Thorium will last somewhat longer
  - Reprocessing can “create” fuel and make it last much longer.
  - Fusion technology is still distant.
- Hydropower:
  - Most major river systems have been dammed.
  - Additional major projects might not be possible due to limited resource and pressure from activists.

But we cannot even consume all the remaining fossil fuels.

The socio-environmental costs of exhausting all the fossil reserves are extremely serious...

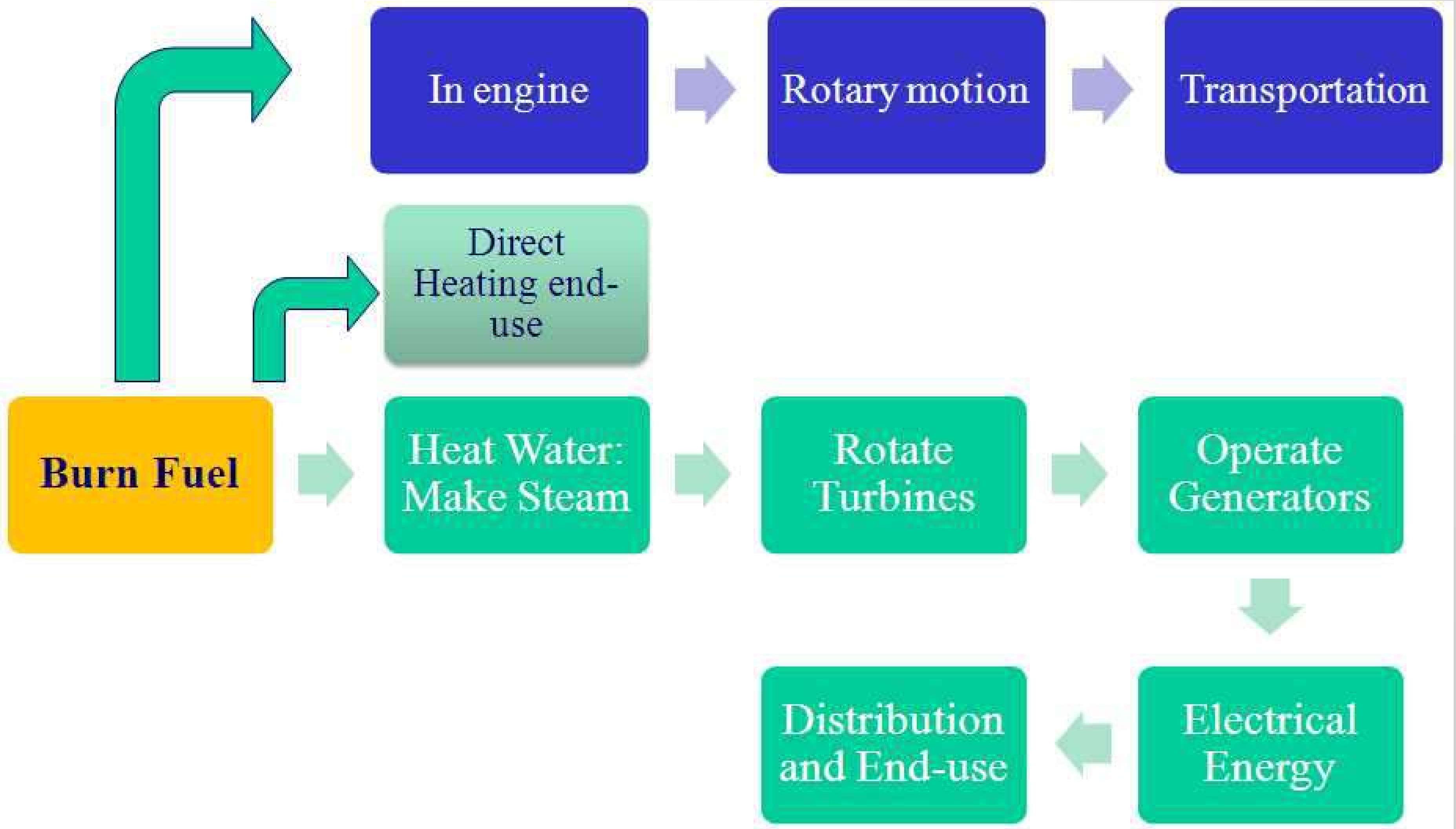
Risks and Costs of Energy Sources

- Fossil Fuels (oil, coal, gas):
  - Greenhouse Gas Emissions, Climate change.
  - Pollution of air, land and water.
- Nuclear:
  - Major accidents, minor accidental releases of radioactive materials
  - Nuclear waste problem.
  - Unaccounted costs of decommissioning and cleanup.
- Hydropower:
  - Large land submergence, loss of habitat,
  - Disruption of riverine ecosystems and floodplain agriculture,
  - Uncompensated oustees, major public agitations.

An Overwiew of Fossil fuels

- Fossil fuels are hydrocarbons that may be used as a fuel found within the top layer of the Earth’s crust.
- Coal, oil and gas are called "fossil fuels" because they have been formed from the organic remains of prehistoric plants and animals
- Coal is crushed to a fine dust and burnt.
- Oil and gas can be burnt directly.

How it works


In engine
Rotary motion
Transportation
Direct Heating end-use
Burn Fuel
Heat Water: Make Steam
Rotate Turbines
Operate Generators
Electrical Energy
Distribution and End-use

Advantages of Fossil Fuels

- Very large amounts of electricity can be generated in one place using coal, fairly cheaply.
- Transporting oil and gas to the power stations is easy.
- Gas-fired power stations are very efficient.
- A fossil-fuelled power station can be built almost anywhere, so long as you can get large quantities of fuel to it

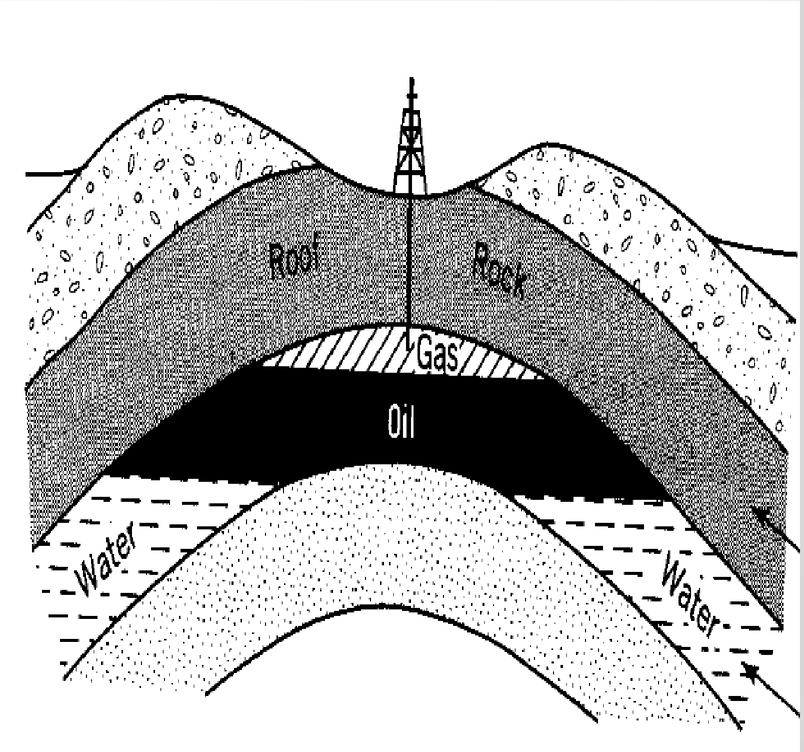
How do we get fossil fuels?

- Petroleum and natural gas—oil wells
- Coal—mining

Petroleum and Natural Gas Extraction

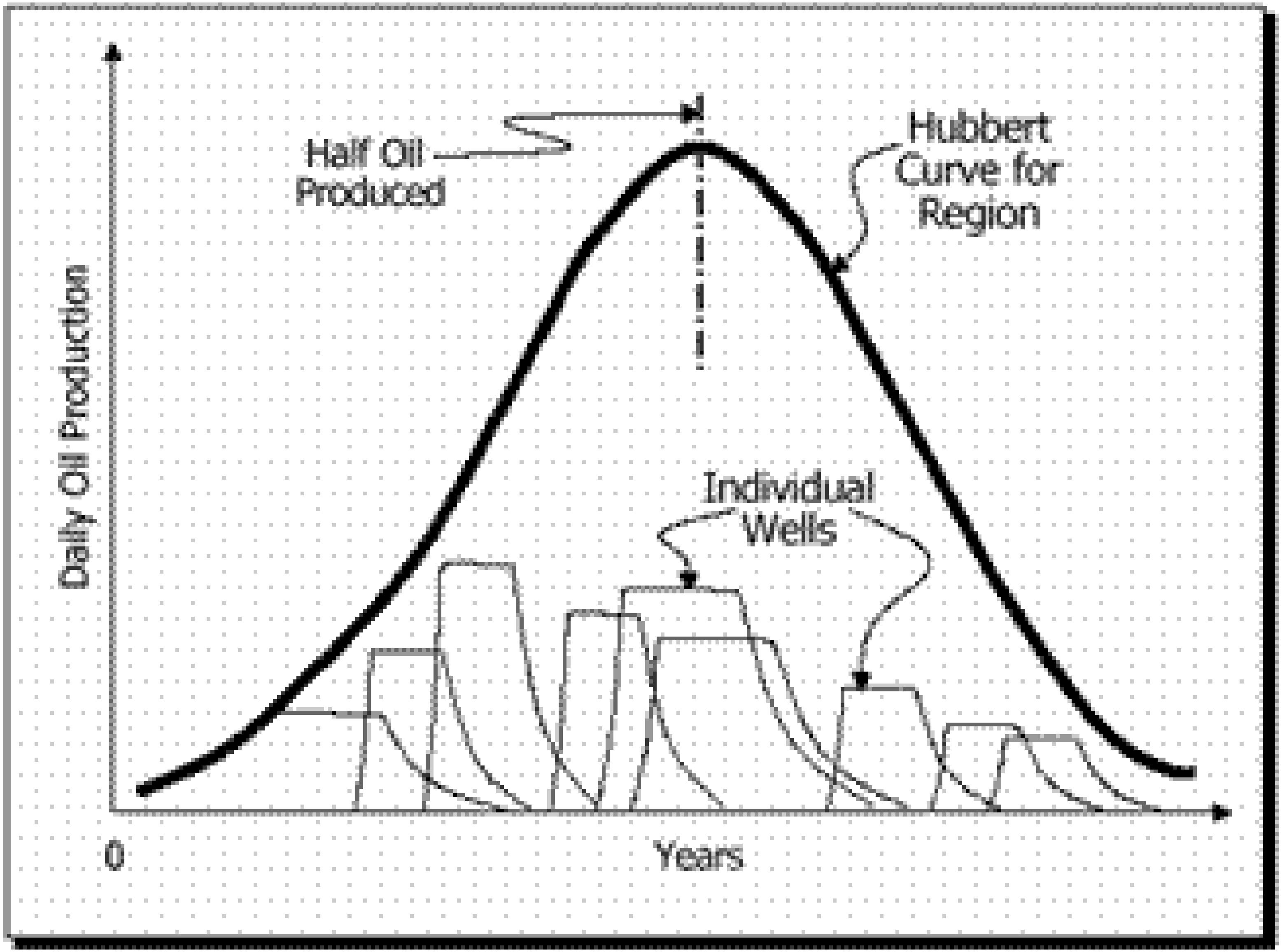
- Crude oil (called "petroleum") is easier to get out of the ground than coal, as it can flow along pipes. This also makes it cheaper to transport
- Natural gas provides around 20% of the world's consumption of energy, and as well as being burnt in power stations, is used by many people to heat their homes.
- It is easy to transport along pipes, and gas power stations produce comparatively **little pollution**

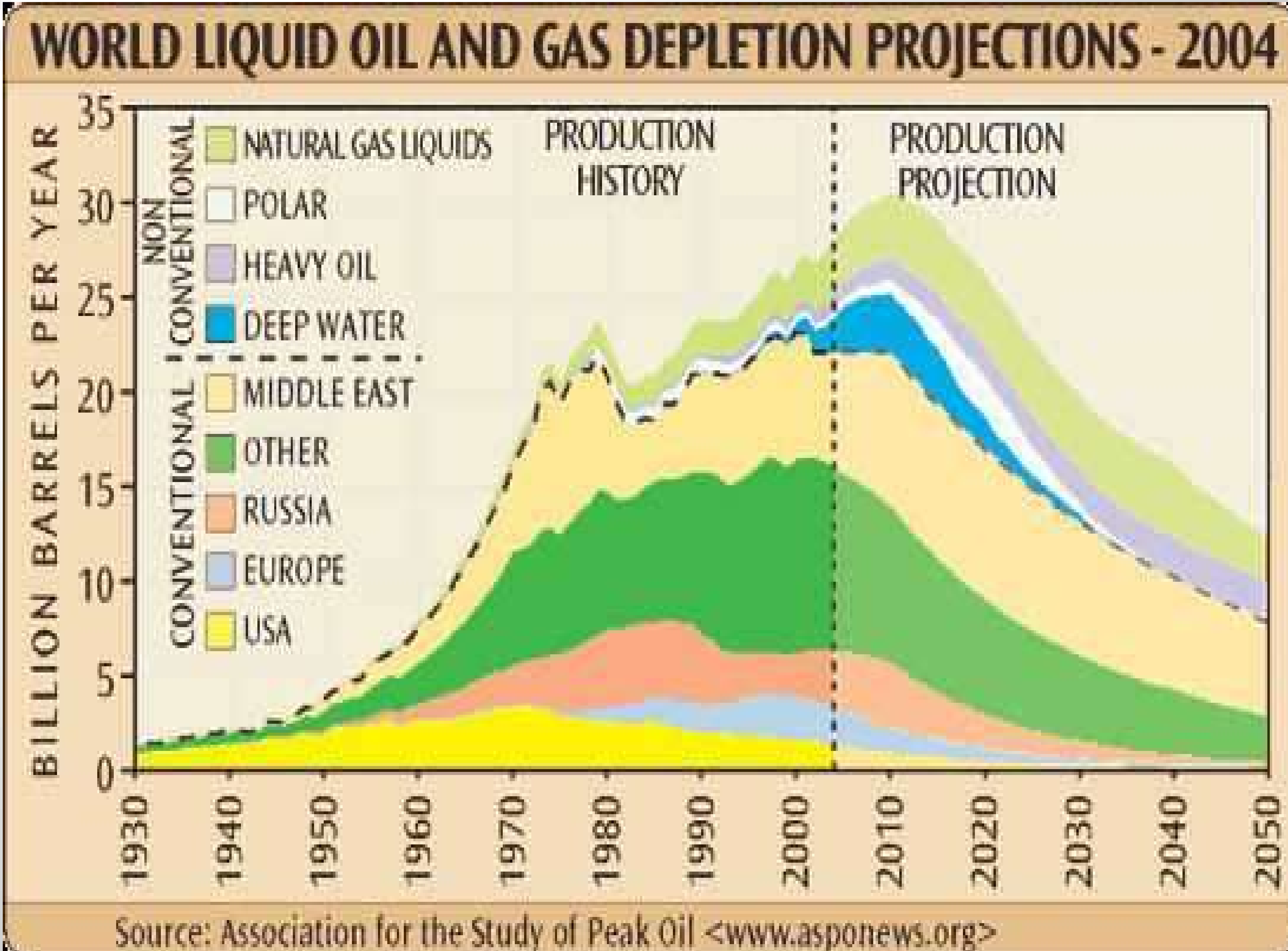
Petroleum and Natural Gas Extraction



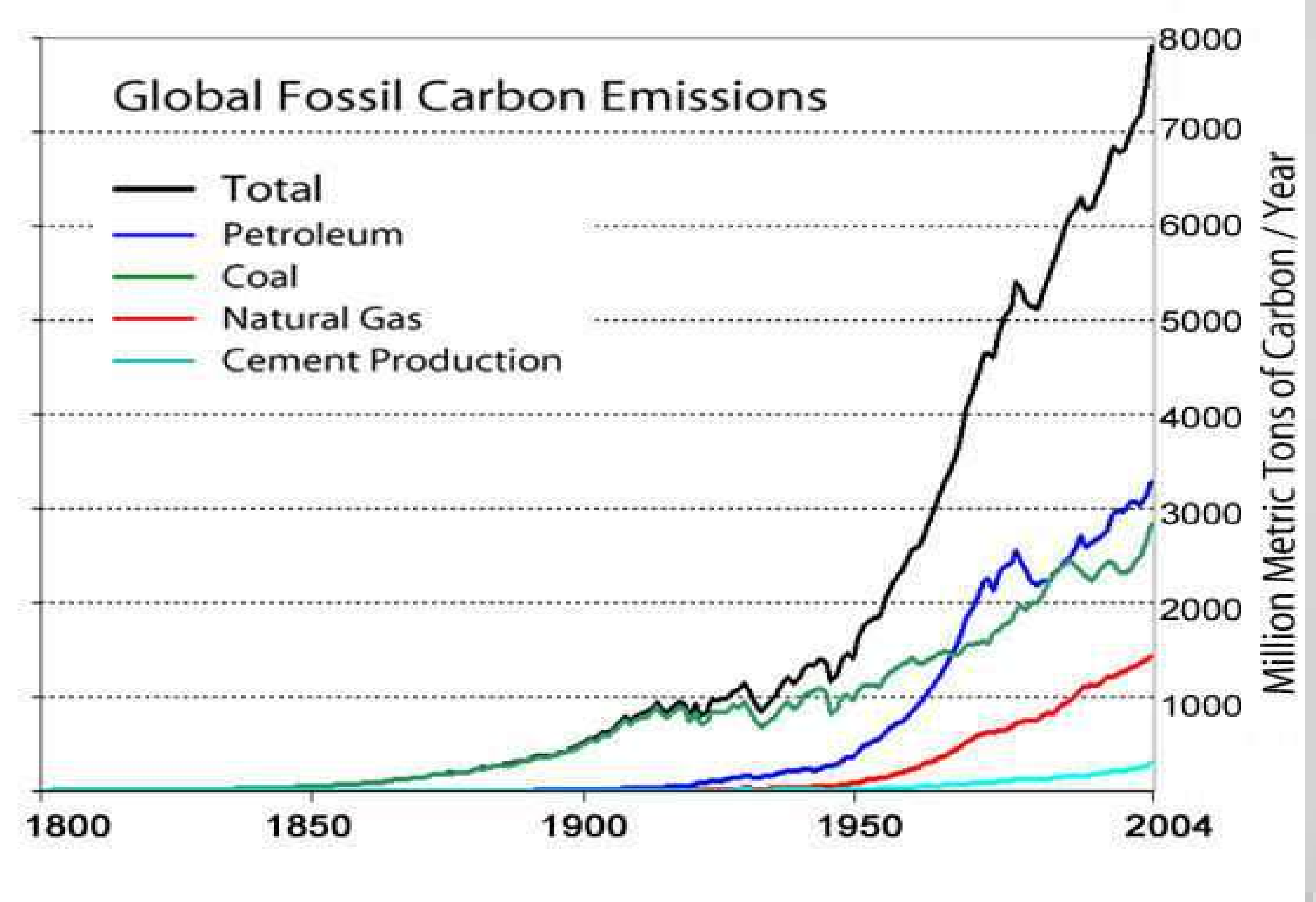
- an average well in the US produces only 11 barrels / day
- In Saudi Arabia an average produces 9600 barrels /day well

HUBBERT CURVE
Regional Vs. Individual Wells

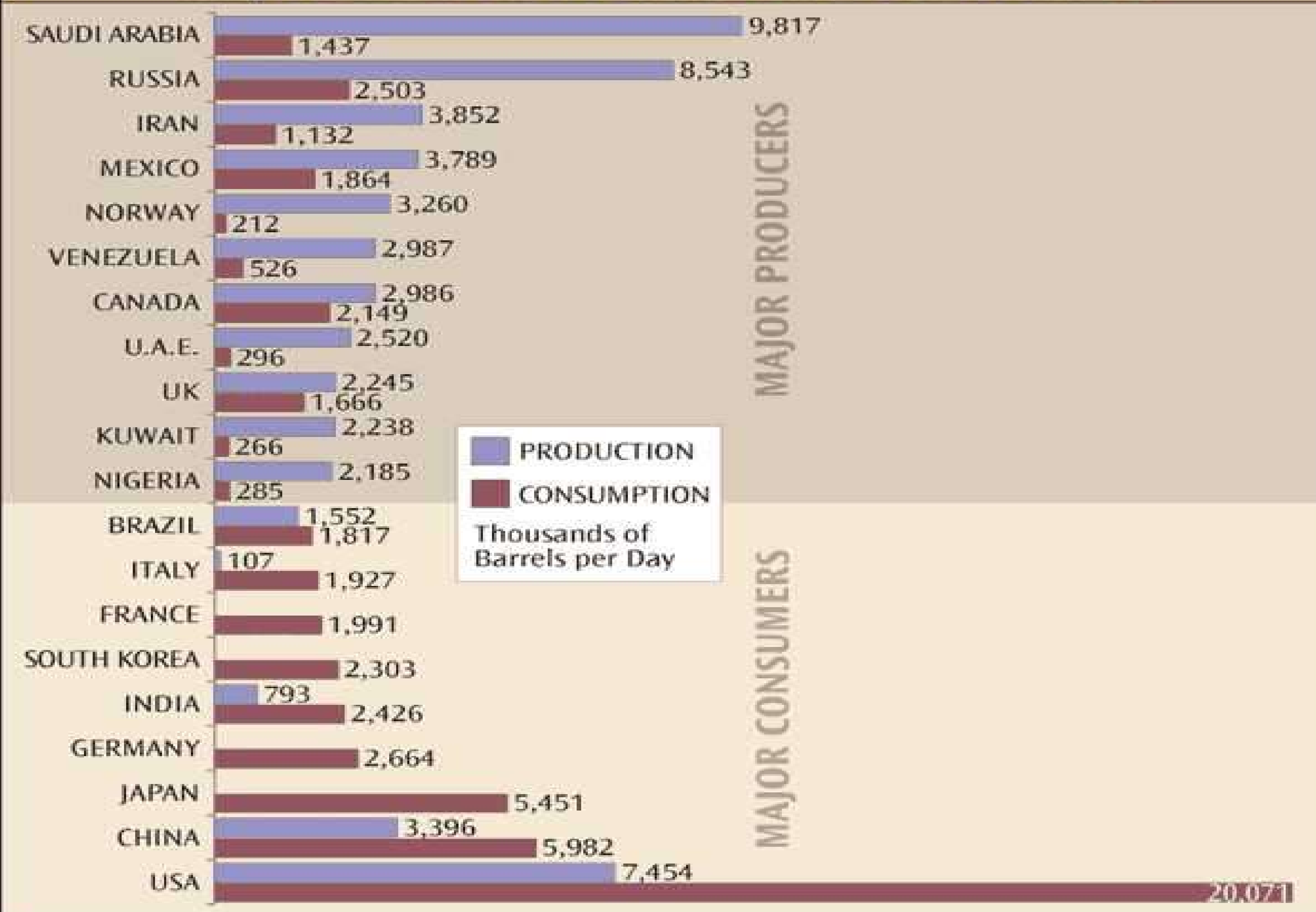



WORLD LIQUID OIL AND GAS DEPLETION PROJECTIONS - 2004
BILLION BARRELS PER YEAR
0
5
10
15
20
25
30
35
NON CONVENTIONAL
NATURAL GAS LIQUIDS
POLAR
HEAVY OIL
DEEP WATER
CONVENTIONAL
MIDDLE EAST
OTHER
RUSSIA
EUROPE
USA
PRODUCTION HISTORY
PRODUCTION PROJECTION
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Source: Association for the Study of Peak Oil <www.asponews.org>

Massive Increase in Fossil Fuel Use and CO_2 emissions.

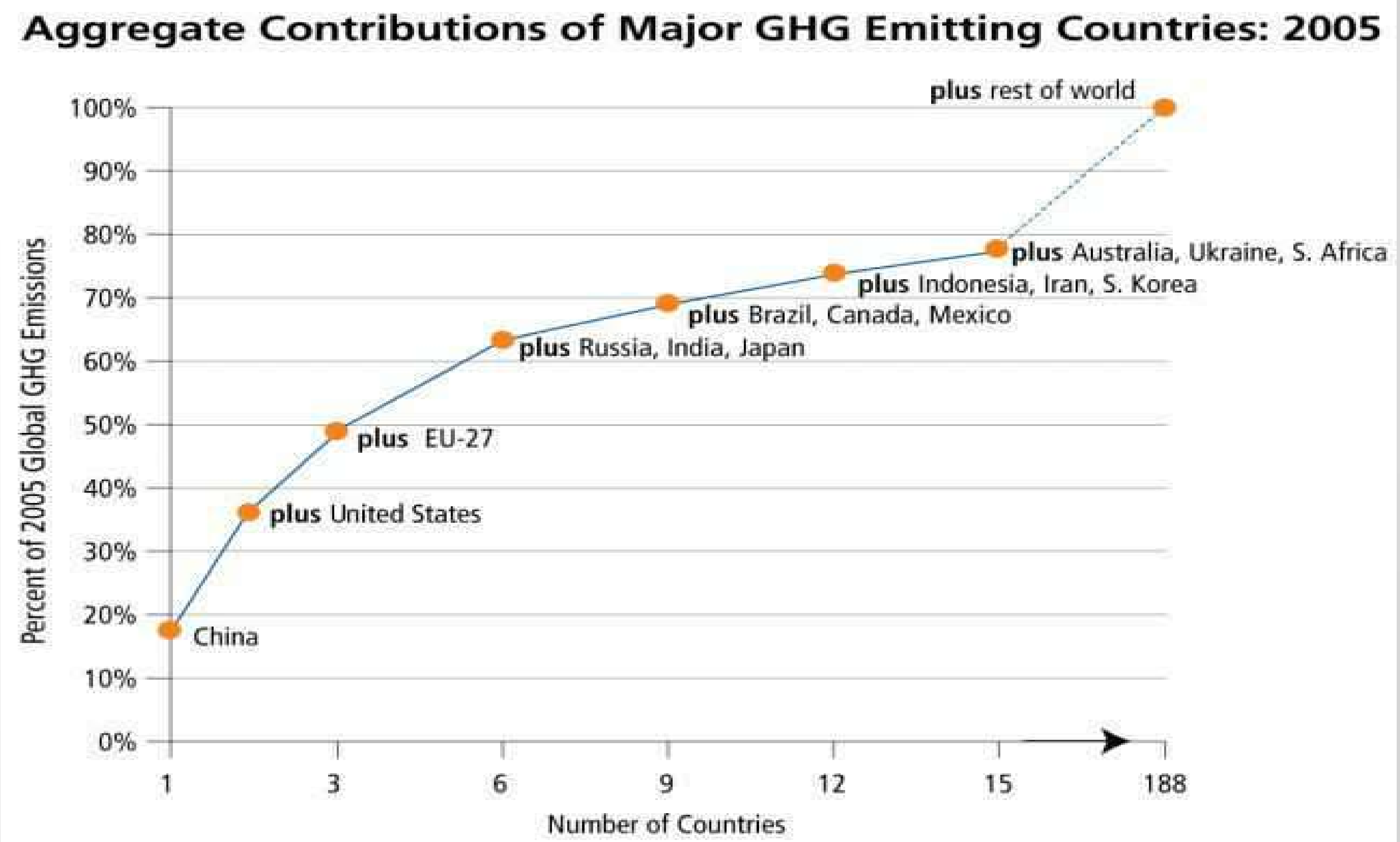


MAJOR OIL PRODUCERS AND CONSUMERS



Source: BP Statistical Review of World Energy 2004 <http://www.bp.com/statisticalreview2004>

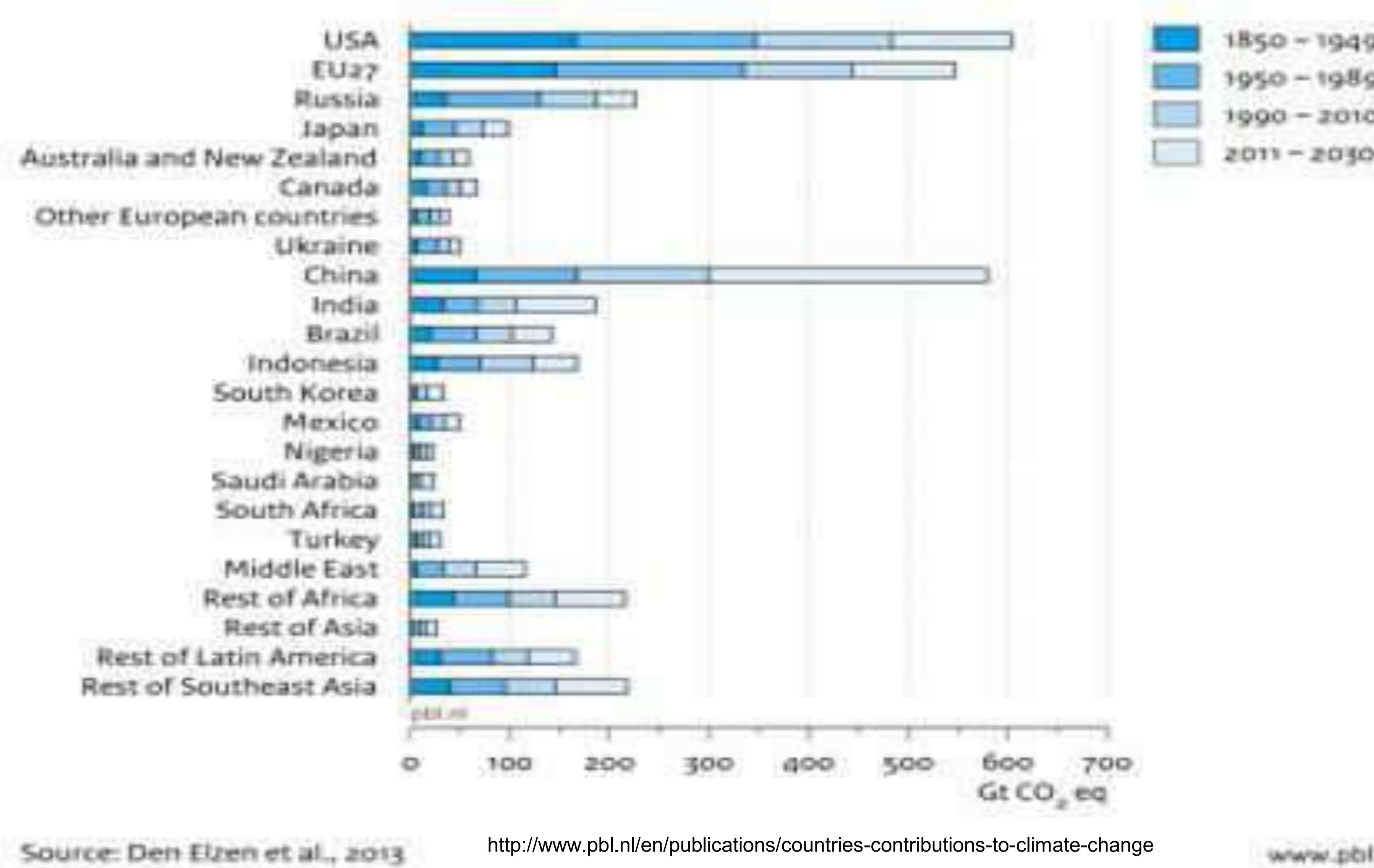
Aggregate Contributions of Major GHG Emitting Countries: 2005



Sources & Notes: WRI, CAIT (http://cait.wri.org). Percent contributions are for year 2005 GHG emissions only. Moving from left to right, countries are added in order of their absolute emissions, with the largest being added first. Figures exclude emissions from land-use change and forestry, and bunker fuels. Adapted from Figure 2.3 in Baumert et al. (2005).

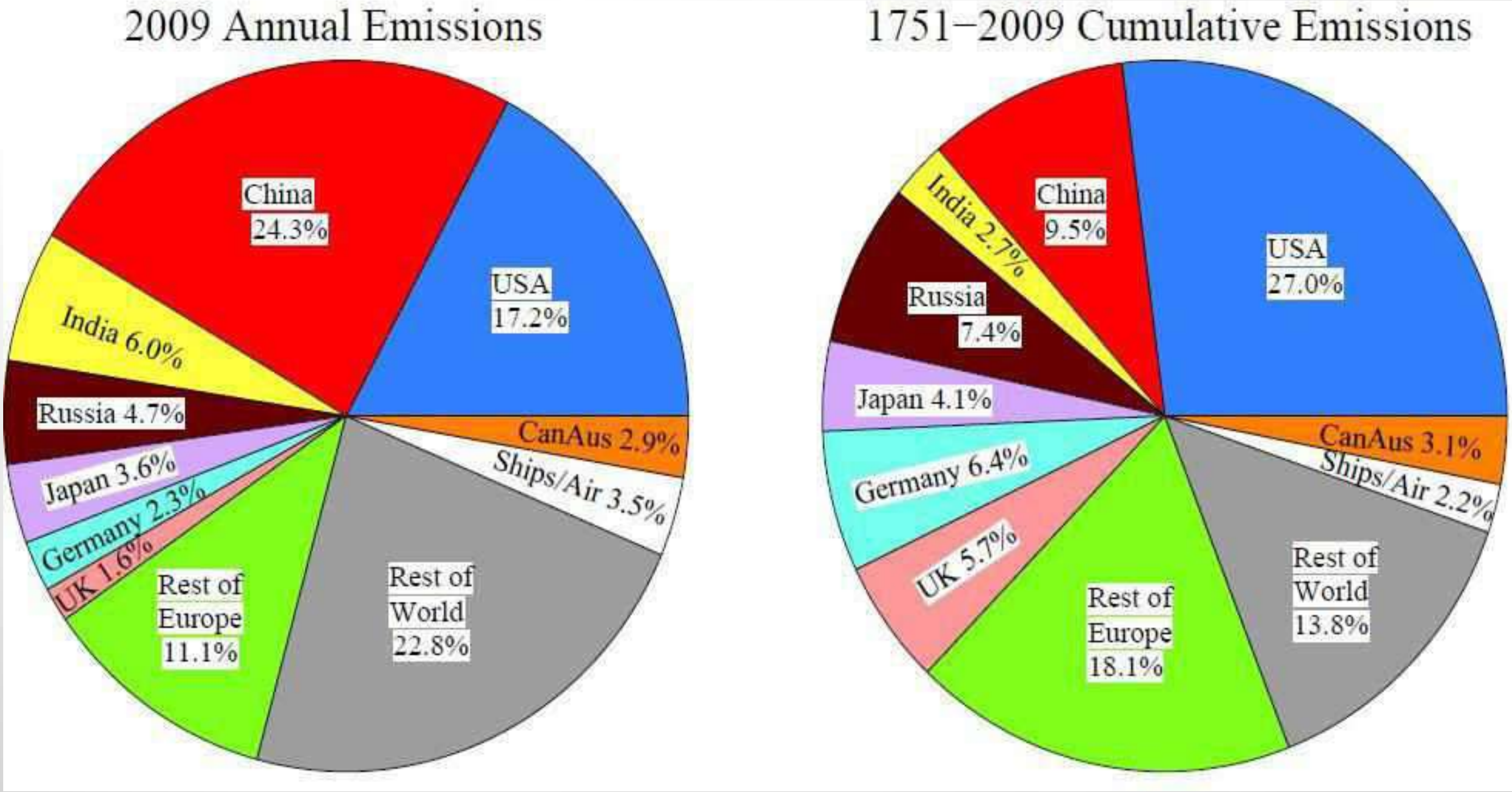
http://www.wri.org/resources/charts-graphs/aggregate-contributions-major-ghg-emitting-countries-2005

Country-Wise Total Cumulative GHG Emissions



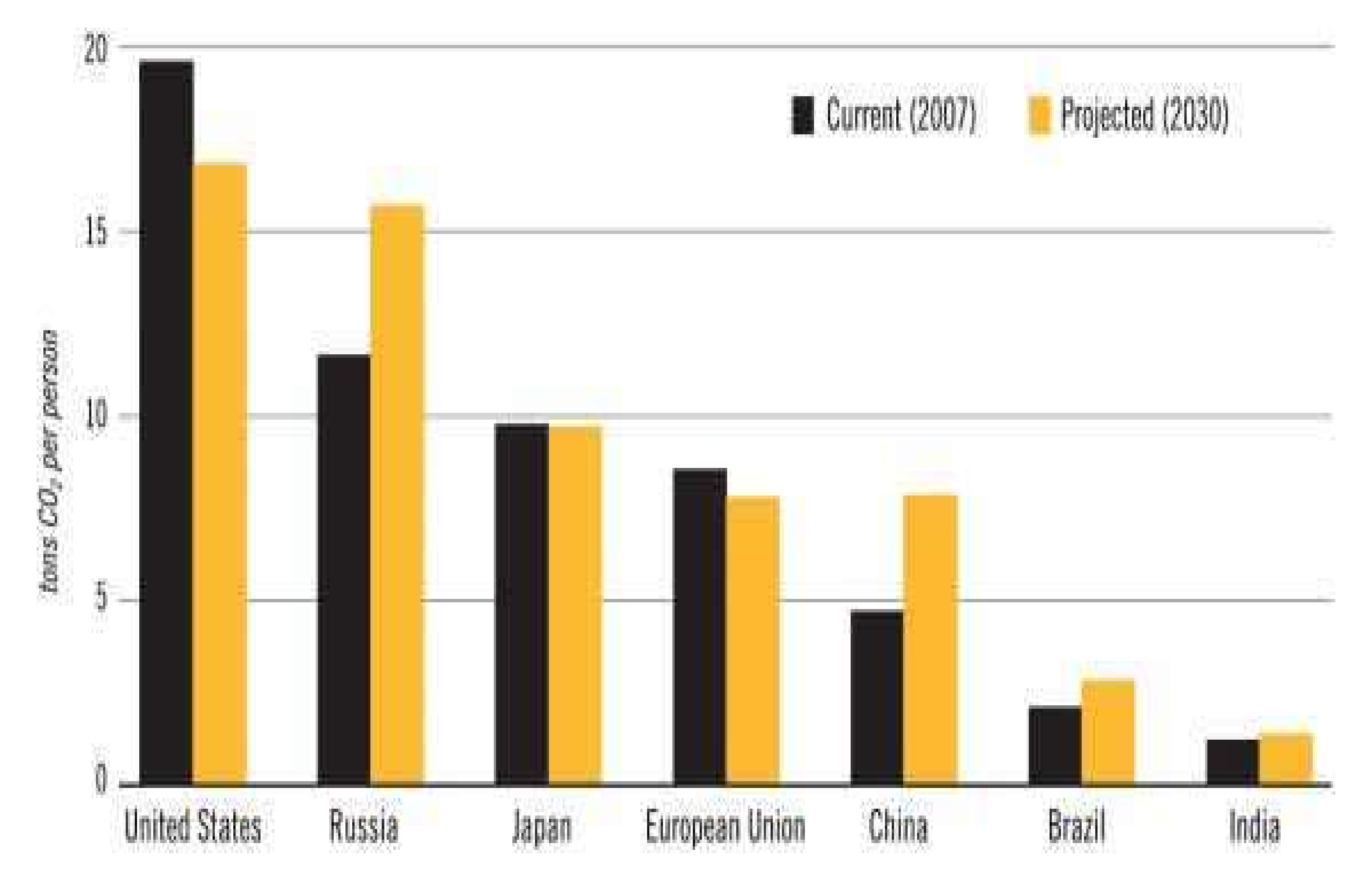
http://www.pbl.nl/en/publications/countries-contributions-to-climate-change

GHG Emissions Countries



http://www.resilience.org/stories/2010-12-09/china-can-slow-global-warming-if-us-won%E2%80%99t

Country-Wise Per Capita CO_2 Emissions



If OIL is running out, why not use COAL?

Surely, there's plenty of it.

Advantages of Coal

- World reserves are relatively more plentiful
- Technology is old and established
- High energy content.
- Solid fuel is easy to transport.
- New technologies such as clean coal technology, gasification, reforming etc. are coming up.

Coal Mining

- A coal mine in Bihar, India.

Emission of gases

Disadvantages of coal

- Being a C-based fuel, causes greenhouse emissions. Coal is the largest contributor to the human-made increase of CO_2 in the air.
- Will run out in 56 years (in 2065) if current acceleration in its use continues.
- Extensive land degradation and pollution due to mining.
- 100s of mi. tons of waste products (fly ash, bottom ash, flue gas desulfurization sludge) containing **mercury, uranium, thorium, arsenic, and other heavy metals**
- Acid rain from high sulfur coal
- Interference with groundwater and water table levels

http://en.wikipedia.org/wiki/Coal#Environmental_effects

Disadvantages of coal

- Contamination of land and waterways and destruction of homes from fly ash spills.
- Dust nuisance
- Coal-fired power plants without effective fly ash capture are one of the largest sources of human-caused background radiation exposure
- Diseases caused by coal-fired power plants~24,000 lives/yr in USA

Methods to control the pollution

- Clean coal technology to burn coal more efficiently and will lesser toxic pollutants emitted.
- Flue gas desulphurisation: removes the acid rain-producing sulphur oxides from the flue gas
- **Yet combustion of coal invariably leads to CO_2 emissions and global warming**

Alright, coal looks quite awful.

But what about Natural Gas?

That’s supposed to be pretty clean, right?

Natural Gas

- Natural gas (mostly CH_4) is more potent as a greenhouse gas than its combustion product, CO_2.
- Was once wasted during oil drilling.
- Often simply flared from an oil well.
- More recently it has been put to use.
- Methane does not get liquefied upon compression at room temperature: CNG is used in public transportation and private vehicles.

Natural Gas

- Low energy density
- Burns cleaner than petrol/diesel.
- NO_x emissions continue to remain a problem.
- World gas reserves: Will last 60 yrs. at current rate of consumption.—Dr. Anthony Hayward CCMI, chief executive of BP 2009.

Effects of Fossil fuels

- Global warming and climate change due to emissions from burning
- Mining, extraction and refining processes are themselves highly energy consuming, and polluting and disrupt human and natural habitats in the vicinity.
- Reduced biodiversity due to impacts on environment.
- Adverse effects on land surface and groundwater.
- Contamination of water bodies, heavy toll on marine ecosystems, due to pollution and oil spills

OK, forget about Fossil Fuels. They all seem bad.

Let's GO NUCLEAR!

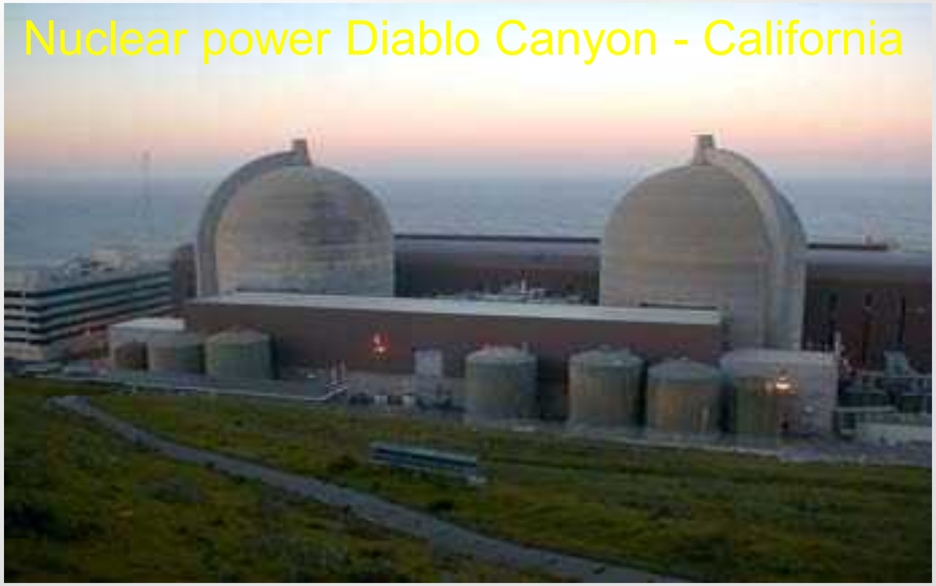
Enormous quantities of cheap energy with no emissions!

Nuclear Energy

- **Nuclear Energy** is energy released due to the splitting (fission) or merging together (fusion) of the nuclei of atom(s).
- **Nuclear power** is most commonly generated using uranium, which is a metal mined in various parts of the world.
- Some military ships and submarines have nuclear power plants for engines

Nuclear Energy

- Nuclear power: 4-largest source of electricity in India.
- As of 2010, India has 19 nuclear power plants in operation generating 4,560 MW while
- 4 others under construction and are expected to generate an additional 2,720 MW.
- In France 79% of electricity comes from nuclear reactors



Advantages

- Nuclear power costs about the same as coal, so it's not expensive to make.
- Does not produce smoke or carbon dioxide, so it does not contribute to the greenhouse effect.
- Produces huge amounts of energy from small amounts of fuel.
- Produces small amounts of waste.
- Nuclear power is reliable.

Disadvantages

- It can be extremely dangerous.
- Nuclear power is reliable, but a lot of money has to be spent **on safety** - if it **does** go wrong, a nuclear accident can be a major disaster.
- Small quantities of spent fuel wastes: huge disposal issue.
- Serious inter-generational ethical issues exist.
- "Nuclear power, which for some countries plays a strategic role in energy security, faces an uncertain future."--World Energy Outlook 2014

Come on, the safety issue is exaggerated!

Don’t nuclear power plants follow strict safety regulations?

Accidents, if at all might have happened in the past and that too in only in the Soviet Union.

International Nuclear Event Scale

7 – Major Accident

6 – Serious Accident

5 – Accident With Wider Consequences

4 – Accident With Local Consequences

3 – Serious Incident

2 – Incident

1 – Anomaly

0 – Deviation (No Safety Significance)

Nuclear Accidents Worldwide

Event Scale	Designation	Example
7	Major Accident	Fukushima Daiichi nuclear disaster (2011), Chernobyl disaster, 26/4/1986. 56 dead; 4,000 cancer fatalities, 600,000 exposed to elevated doses of radiation.
6	Serious Accident	Kyshtym disaster at Mayak, Soviet Union, 29/9/1957. 70-80 tons of highly radioactive material into the environment. Impact on local population is not fully known.
5	Accident With Wider Consequences	• **Windscale fire** (UK), 10/10/1957. Radionuclide released , 200-240 thyroid cancer cases expected. • **Three Mile Island accident** (US), 28/3/1979Some radioactive gases were released into the atmosphere. • **Goiânia accident** (Brazil), 13/9/1987. An unsecured caesium chloride radiation source left in an abandoned hospital was recovered by squatters unaware of its nature and sold at a scrapyard. 249 people contaminated; 4 died.

Nuclear Accidents Worldwide

Event Scale	Designation	Example
4	Accident With Local Consequences	• Sellafield (United Kingdom) - 5 incidents 1955 to 1979[3] • SL-1 Experimental Power Station (United States) - 1961, reactor reached prompt criticality, killing three operators • Saint-Laurent Nuclear Power Plant (France) - 1980, partial core meltdown • Buenos Aires (Argentina) - 1983, criticality accident during fuel rod rearrangement killed one operator and injured 2 others • Jaslovské Bohunice (Czechoslovakia) - 1977, contamination of reactor building • Tokaimura nuclear accident (Japan) - 1999, three inexperienced operators at a reprocessing facility caused a criticality accident; two of them died

Nuclear Accidents Worldwide

- Worldwide 99 accidents at nuclear power plants.
- Of which 57 occurred since the Chernobyl disaster
- 57% (56 out of 99) occurred in the USA.[7]
- Serious nuclear power plant accidents include:
  - the Fukushima Daiichi nuclear disaster (2011),
  - Chernobyl disaster (1986),
  - Three Mile Island accident (1979)
  - SL-1 accident (1961).[8]
- Highest cumulative loss among energy-related accidents.

The French Atomic Energy Commission (CEA) has concluded that technical innovation cannot eliminate the risk of human errors in nuclear plant operation.

http://en.wikipedia.org/wiki/Nuclear_and_radiation_accidents

- 99 nuclear reactor accidents world-wide is not a big deal! It shows how safe the technology is!
- Auto accidents happen in millions.

- Radioactivity-related accidents/leaks can lay waste contaminated land for thousands of years.
- Immediate deaths (which are very few) are not the best way of quantifying damage.
- Affects exposed persons and future generations (mutations, birth defects).

Radioactive Waste Disposal

- The cumul. total of spent nuclear fuel > 700,000 tonnes.
- Radioactive wastes can remain a concern for thousands of years and several half-lives.
- Long term and inter-generational health impacts should be examined critically.
- Practical studies only consider up to 100 years as far as effective planning and cost evaluations are concerned.
- To date, no country has opened a permanent disposal facility to isolate the most long-lived and highly radioactive waste produced by commercial reactors--World Energy Outlook 2014
- If safe disposal as promised by various governments and nuclear agencies is so easy then why did they do this...?

Illegal Dumping—Mafia

- ‘Ndrangheta mafia clan accused of trafficking and illegally dumping nuclear waste.
- A manager of the Italy’s state energy research agency “Enea” paid the clan to get rid of 600 drums of toxic and radioactive waste from Italy, Switzerland, France, Germany, and the US, with Somalia as the destination, where the waste was buried after buying off local politicians.
- Enea employees are suspected of paying the criminals to take waste off their hands in the 1980s and 1990s.
- Ndrangheta claim to have been paid to sink ships with radioactive material for the last 20 years.

http://en.wikipedia.org/wiki/Toxic_waste_dumping_by_the_%27Ndrangheta

Reading Material:

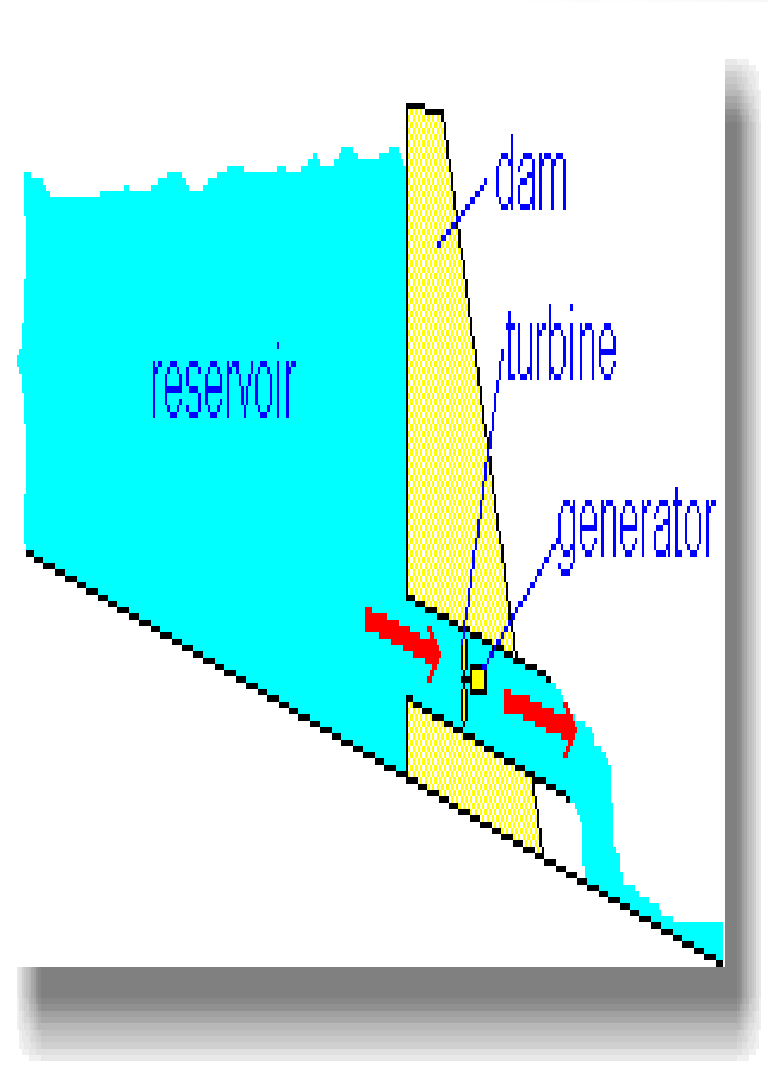
- Pros and Cons of the Nuclear Energy Debate.
- Whole Earth Discipline (pro-nuclear)
- Four Nuclear Myths: A Commentary on Stewart Brand's Whole Earth Discipline and on Similar Writings (pro-renewables)

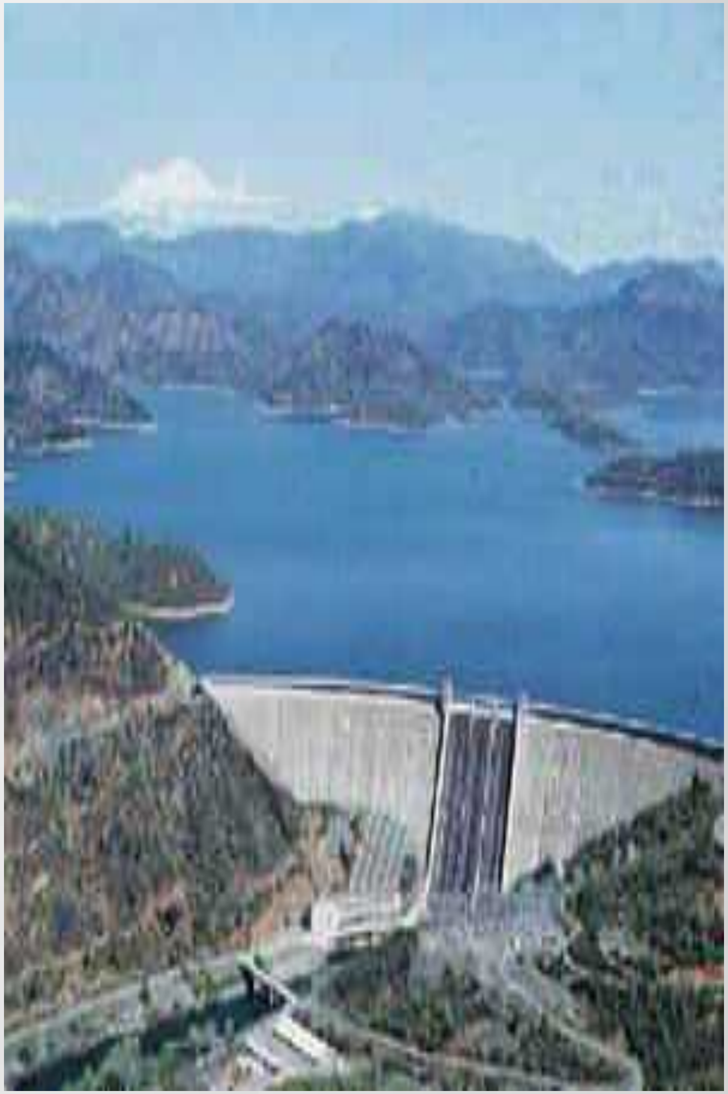
OK, just stop!

Let’s not get into a debate...

What about plain and simple Hydroelectric Power?

There couldn't possibly be any problem with it!





Water generated – Hydroelectric
Shasta dam in California

Hydroelectric Power: Advantages

- Low running costs
- No waste or pollution.
- High reliability, continuous generation.
- Electricity can be generated constantly
- Easy to step up or step down generation to meet peak demand.
- Allied benefits related to creation of reservoirs such as irrigation, flood control, recreation.

Hydroelectric Power: Disadvantages

- High initial costs
- Huge areas submerged: displacement of thousands of people and habitat destruction.
- Deforestation in the catchment
- Loss of fertile riverbed land in catchment
- Loss of fertile land downstream due to water logging
- Greenhouse gas emissions from submerged and waterlogged land

Secure Energy Systems

- “The foundation of a secure energy system is:
  - to need less energy in the first place,
  - Then to get it from sources that are inherently invulnerable because they're diverse, dispersed, renewable, and mainly local.
- Any highly centralised energy system -- pipelines, nuclear plants, refineries -- invite devastating attack. But invulnerable alternatives don't, and can't, fail on a large scale.”

--Amory Bloch Lovins (physicist, environmental scientist, writer, and Chairman/Chief Scientist of the Rocky Mountain Institute.)

Well…then it looks like we cannot depend on any of the conventional energy sources.

But there are alternative forms of energy right?

Why can't we use them?

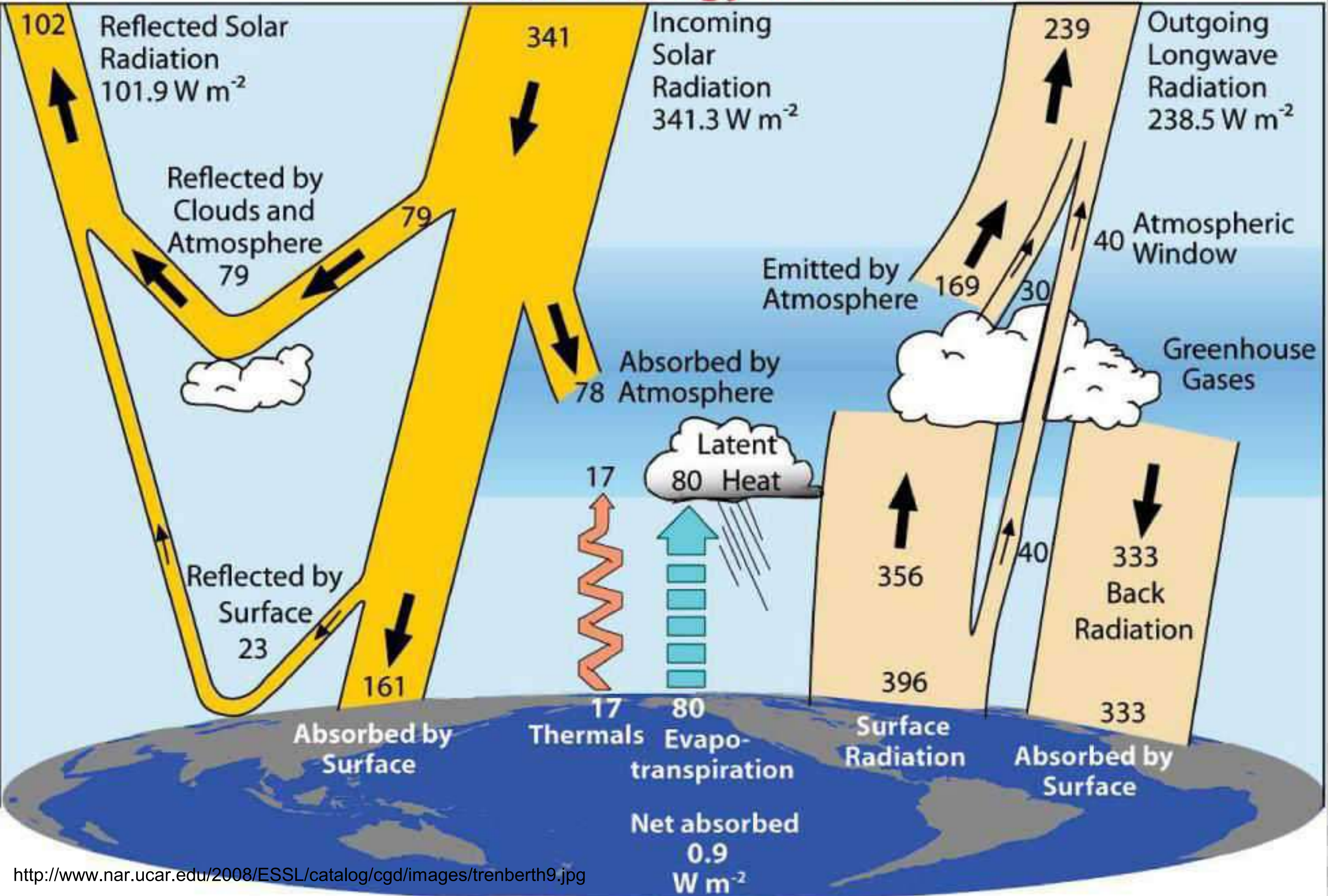
Outline

- Units and Terms
- Energy Resources, Depletion and Risks
- Environmentally Benign Forms of Energy
- Efficiency Measures
- Reduction in Consumption—Individual Perspective

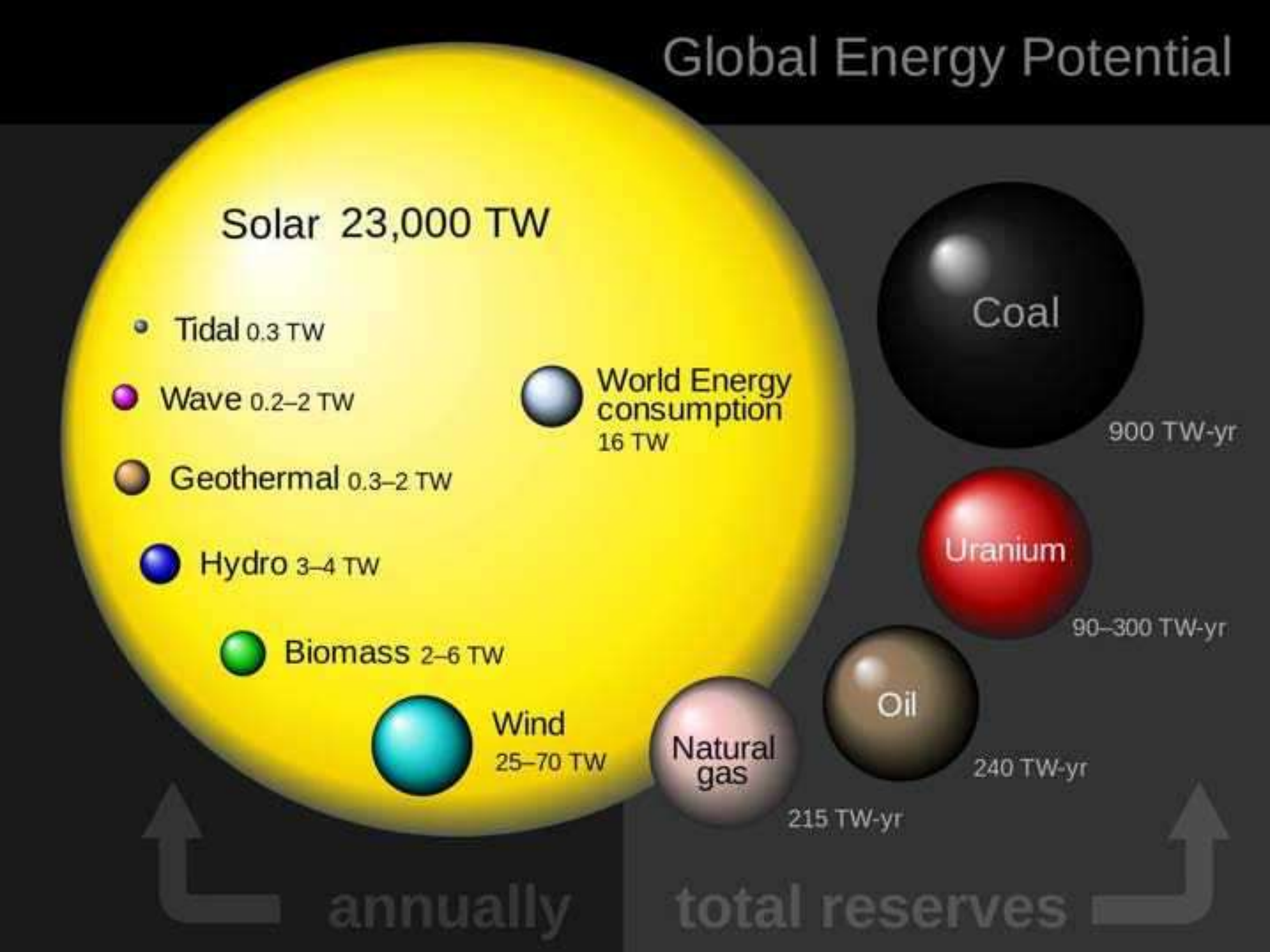
Alternative Energy: Good News

- The continuous/renewable energy resources on Earth far exceed present human needs.
- In general, we have the technology to harness them.
- But some gaps exist...
- That's where there is a tremendous scope for R&D and huge potential markets!

Global Energy Flows W m^{-2}

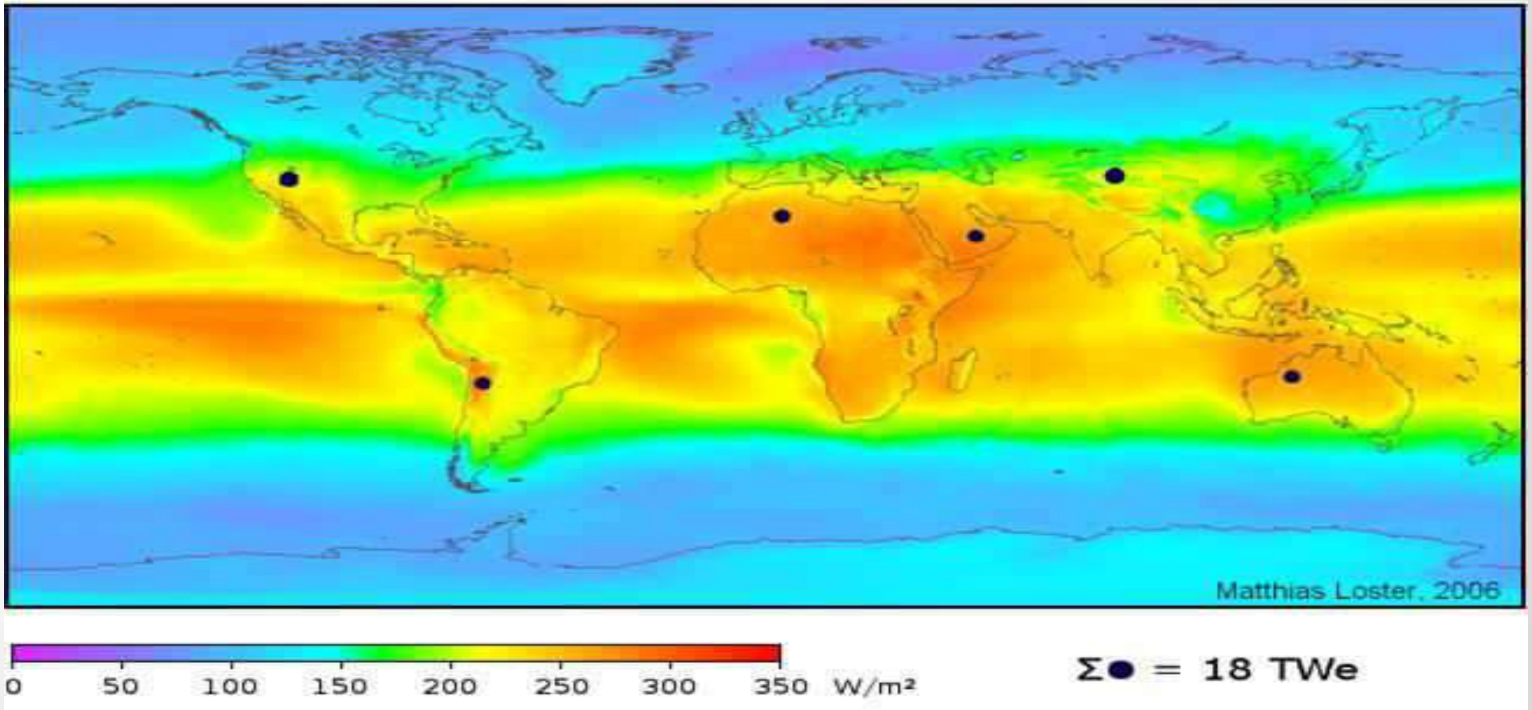


http://www.nar.ucar.edu/2008/ESSL/catalog/cgd/images/trenberth9.jpg



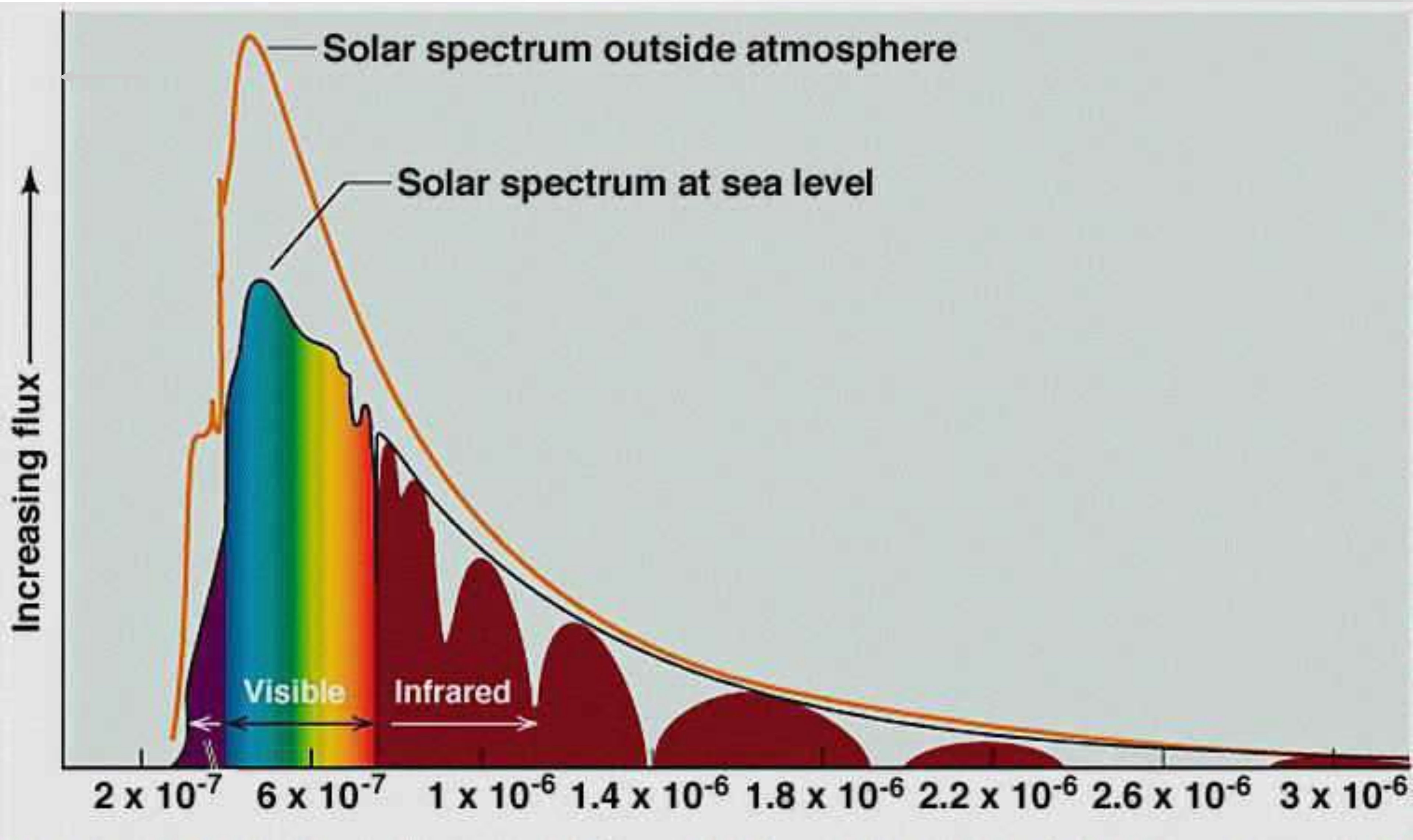
Global Energy Potential
Solar 23,000 TW
Tidal 0.3 TW
Wave 0.2–2 TW
Geothermal 0.3–2 TW
Hydro 3–4 TW
Biomass 2–6 TW
Wind 25–70 TW
World Energy consumption 16 TW
Coal
900 TW-yr
Uranium
90–300 TW-yr
Oil
240 TW-yr
Natural gas
215 TW-yr
annually
total reserves

We have Enough Renewable Energy!



- All human energy and fuel needs, supplied by black spots of solar cell areas
- At conversion efficiency of 8%; cloud cover accounted for.
- Colors show the local solar irradiance averaged over three years from 1991 to 1993 (24 hours a day)
- http://www.ez2c.de/ml/solar_land_area/

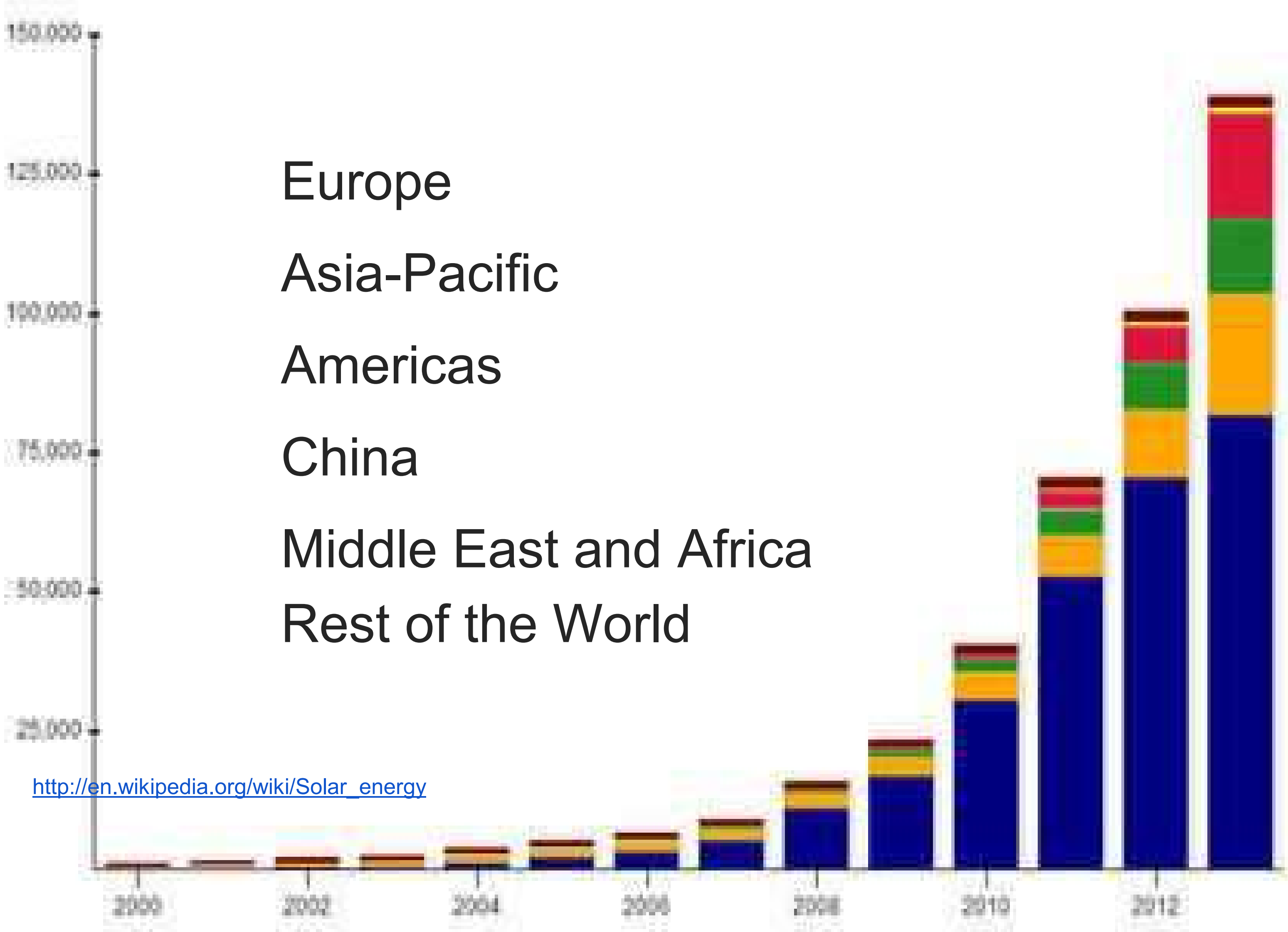
The Solar Spectrum



Applications of Solar Energy

- Heating and cooling of residential building.
- Solar water heating.
- Solar cookers
- Solar engines for water pumping.
- Food refrigeration
- Solar furnaces
- Solar electric power generation by solar ponds, reflectors with lenses.
- solar photovoltaic cells, which can be used for conversion of solar energy directly into electricity.

Worldwide Growth of PV



http://en.wikipedia.org/wiki/Solar_energy

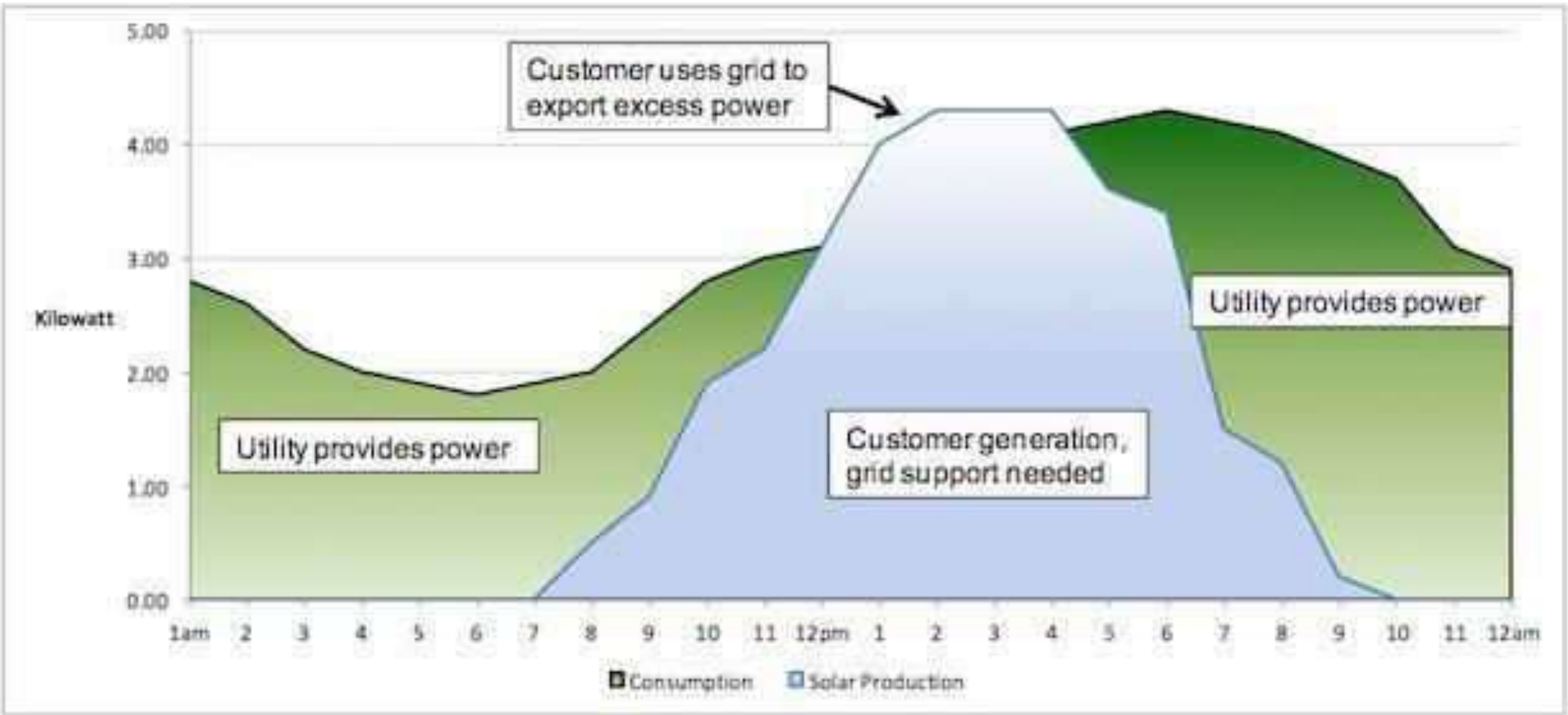
Overcoming Disadvantages (Solar)

- **Solar energy is available intermittently: dependent on weather conditions and the time of day**
- **Luckily, large amount of energy demand is during daytime.**
- **Grid-connected solar systems are most convenient.**
  - During the night and cloudy days, traditional methods (fossil/nuclear/hydel) can be used to supply power to the grid.
  - Minimize the need to store the energy. The consumer can save battery costs (~ 50% of PV system costs).
  - It will greatly decrease our dependence on fossil fuels.
  - Enables private investment in the nation's energy infrastructure.
  - Captive energy for the consumer (individual/ organization)
  - Feed-in tariffs/net metering can enable the consumer to sell extra power generated.

Overcoming Disadvantages (Solar)

- Grid connected solar systems have some challenges
  - Most states do not allow grid connected solar with feed-in tariffs/ net metering.
  - The grid in many countries including India, is unreliable and subject to frequent and extended blackouts and brownouts.
  - Adequate studies and governing standards and mechanisms for ensuring reliability and power quality of grids connected to numerous distributed micro-generation units are missing.

Net Metering



http://blogs-images.forbes.com/jamesconca/files/2014/11/SolarGrid.jpg

Overcoming High Cost (Solar)

- High initial cost of solar cells
  - Coal electricity costs $0.08-0.20 cents/kWh,
  - PV electricity costs $0.50-1.00/kWh.
- Fossil fuel energy costs do not include the socio-environmental costs.
  - If all costs are internalized, solar might easily be a winner.
- Cheaper PV cells are available. Conversion efficiency is intimately tied to cost.
  - Crystalline Si and multijunction cells-- more efficient, more expensive
  - Amorphous Si--low efficiency but cheap.

Building Integrated Photovoltaics (BIPV)

http://www.google.co.in/imgres?imgurl=http://media.treehugger.com/assets/images/2011/10/20090421-building-integrated-solar-tiles.jpg&imgrefurl=http://www.treehugger.com/renewable-energy/srs-energy-launches-building-integrated-photovoltaic-panels-for-clay-tile-roofs.html&h=315&w=468&tbnid=T0EGjVO6G6wA2M:&zoom=1&docid=TVp_PrG4vGc-uM&ei=K_gSVdmXC9OQuATI3oKoAg&tbm=isch&ved=0CEsQMyglMCU

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content/uploads/2014/07/bipv-1.jpg&imgrefurl=http://lightbysolar.co.uk/building-integrated-photovoltaics/&h=800&w=1200&tbnid=CYtiuXAIUHtKQM:&zoom=1&docid=meqc4QGMX5haHM&ei=K_gSVdmXC9OQuATI3oKoAg&tbm=isch&ved=0CEwQMygmMCY

Overcoming Low Efficiency (Solar)

- Overall efficiency of most PV systems can be is about 10-14%.
- **Some new ideas promise to be disruptive innovations (drastically more advantageous):**
  - Solar thermal, with cogeneration (solar energy utilization >60%)
  - Concentrated photovoltaics, with heat recovery (solar energy utilization > 72%)

[Watch Video: Solar Co-Generation]

Overcoming Disadvantages (Solar)

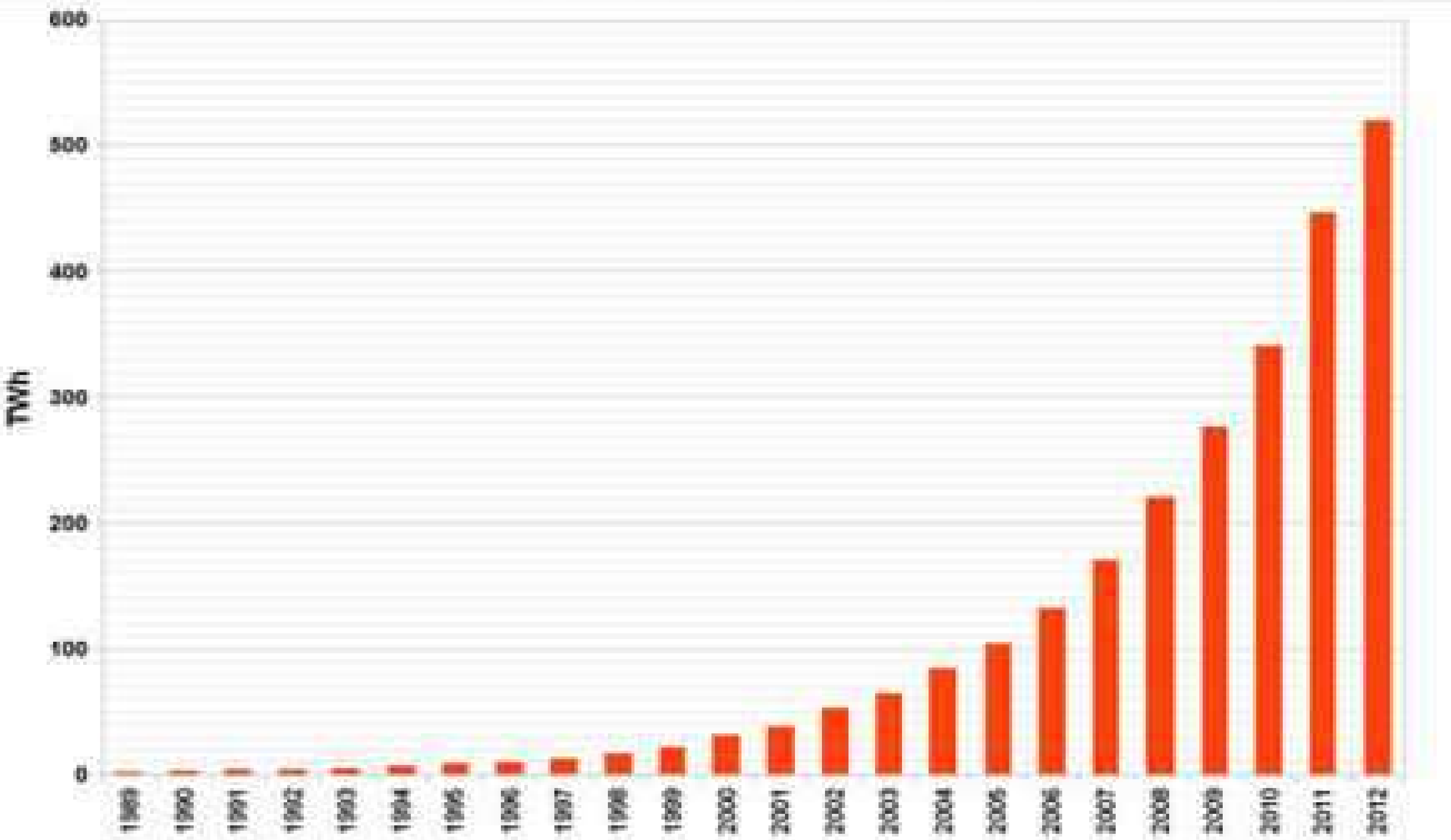
- Solar energy is a diffuse source. (low energy density).
- To harness it especially in the form of heat, we can concentrate it.
- Solar panels can be integrated into building roofs or other surfaces so that multiple functions can be served.

Solar reflector used for cooking

Solar Thermal

http://www.21stcentech.com/wp-content/uploads/2011/08/solar-thermal-9-storage-capacity.jpg

Worldwide Growth of Electricity Generation from Wind



http://en.wikipedia.org/wiki/Wind_power

Main Barriers for Renewable Energy

- Intermittence (wind, solar, wave, tidal, etc.)
- Unpredictability or poor predictability.
- Diffuseness or low energy density
  - (e.g. daily average solar insolation in India ~ 4-7 KWh/m^2)
- Lack of efficient and environmentally acceptable large-scale energy storage.
  - E.g. batteries are not practical for a very large scale and most battery materials are harmful to the environment.

Main Barriers for Renewable Energy

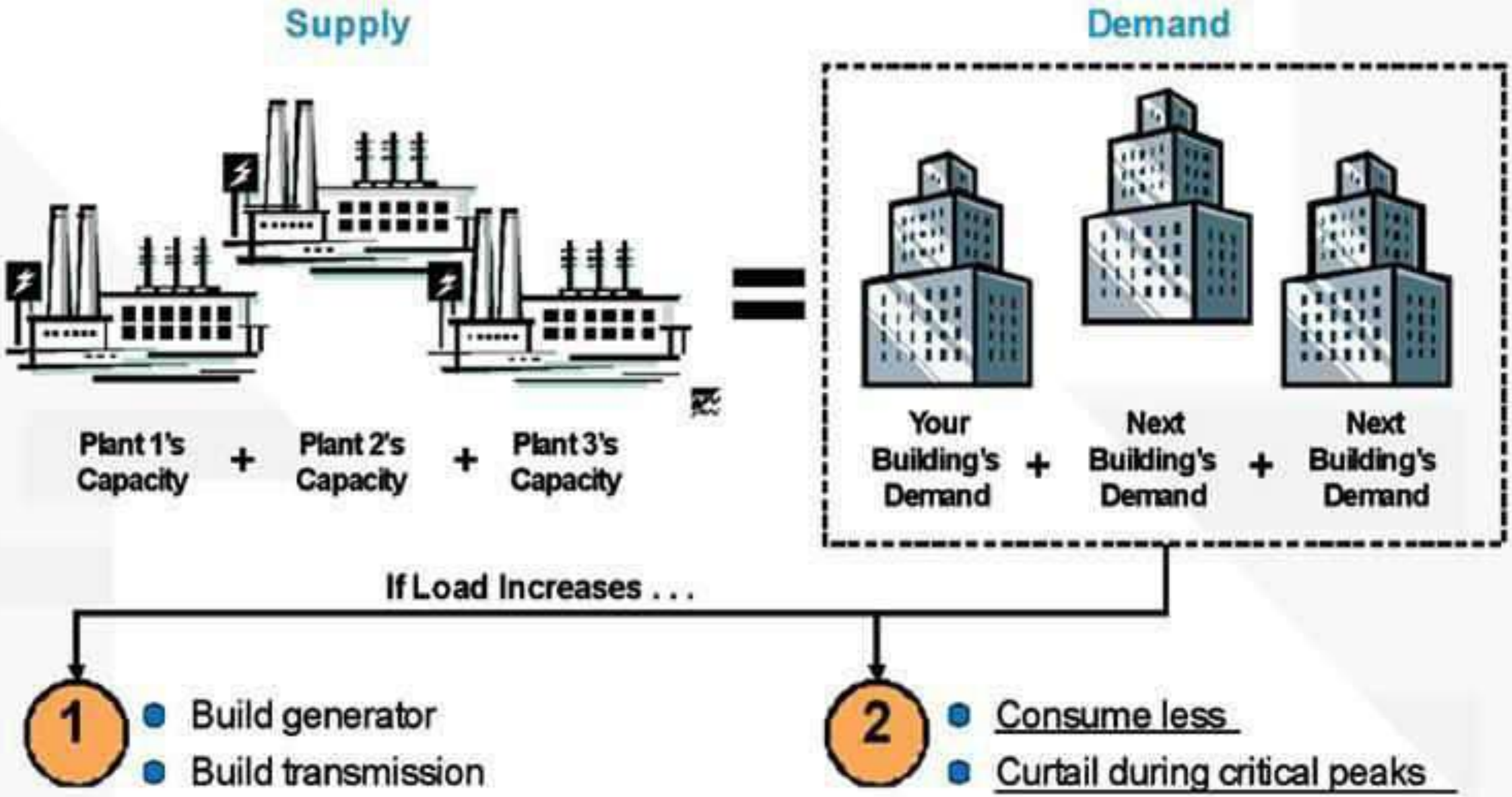
- Commercial and governmental policy factors make it difficult for any alternative energy form to compete.
  - e.g. government subsidies and support for conventional energy (fossil fuels and nuclear).
  - Fossil-fuel subsidies ($550 bi. in 2013) – more than four-times those to renewable energy – are holding back investment in efficiency and renewables. --World Energy Outlook 2014
  - Socio-environmental costs of conventional energy forms are not internalized.
  - i.e. the price we pay for it does not include the socio-environmental damage it causes.

Main Barriers for Renewable Energy

- Poor grid capability to handle high variability of renewables.
  - Better wind and weather prediction models; more locations and hourly prediction.
  - Limited capability of infrastructure to enable inter-state transfers.
  - Smart-grids to enable load balancing.

What is Demand Response?

Grid operators must meet peak demand reliably with all available resources. Enabling the demand side of the equation optimizes resources.

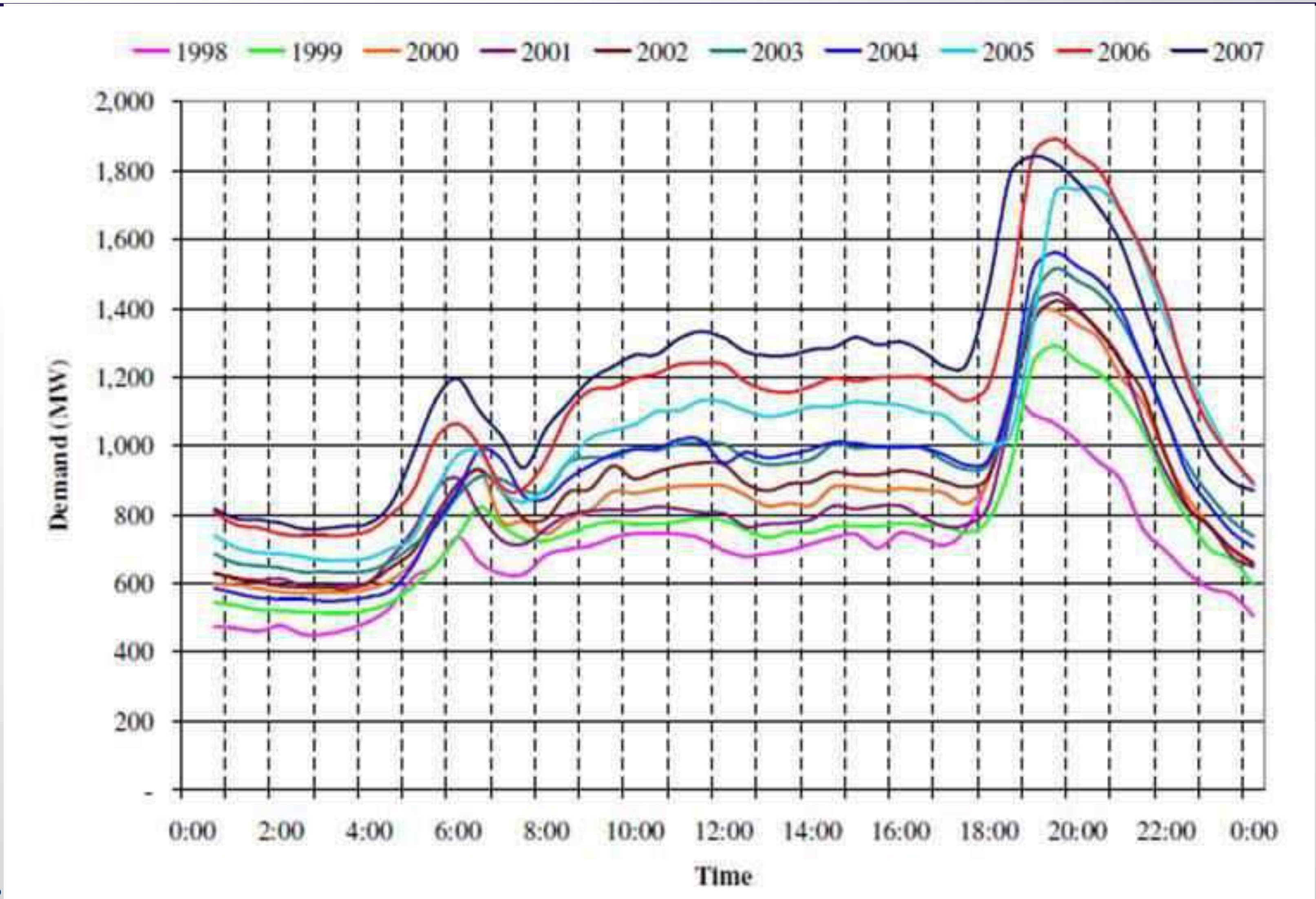


1.
- Build generator
- Build transmission
- Build distribution

2.
- Consume less
- Curtail during critical peaks
- Shift consumption
- Self generate

http://esm.versar.com/pprp/ceir15/images/Box_4c.jpg

Daily Load Curve



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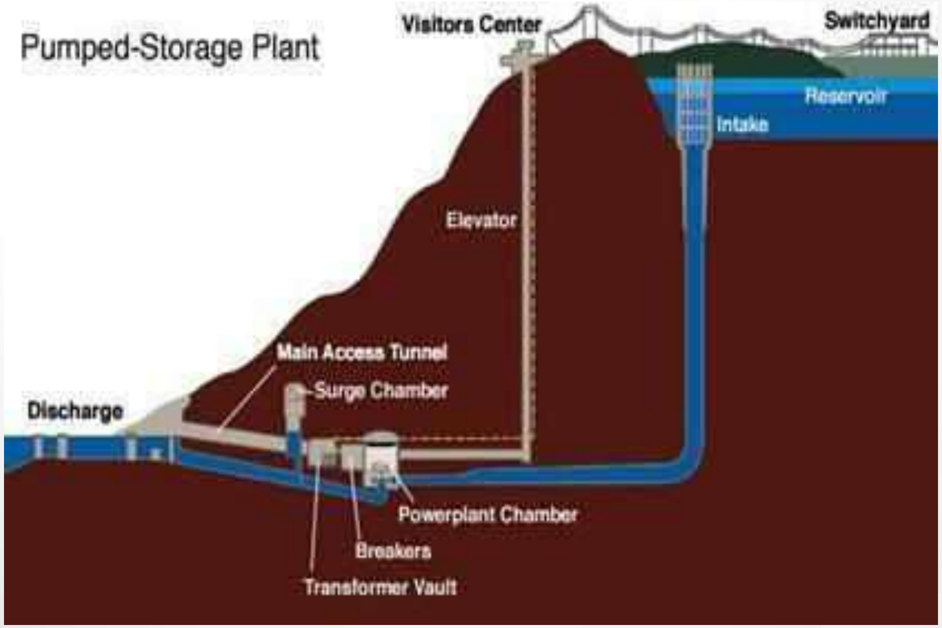
p1gmgg/UWJSnefKJ1I/AAAAAAAAHas/upSlyLK4I1k/s1600/Electricity_Daily_Load_Curve_upto_2007_Sri_Lanka_Consumer_Electricity_Tariff_Need_is_for_a_Long_Term_Vision_Eng_Parakrama_Jayasinghe.JPG

Need For Utility-Scale Storage



https://wattsupwiththat.files.wordpress.com/2014/07/clip_image0051.jpg

Round-trip energy efficiency: 70-80%

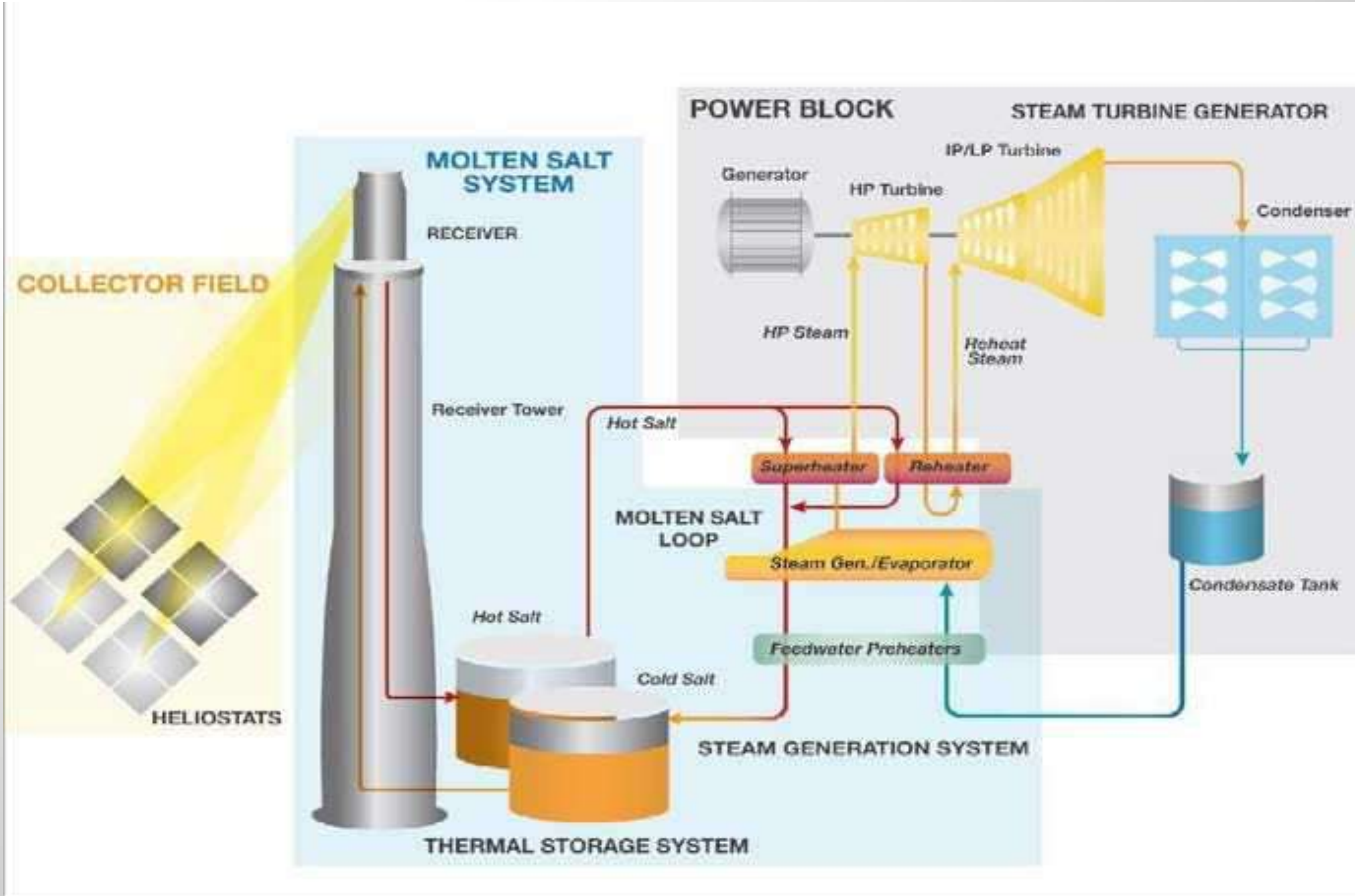
https://en.wikipedia.org/wiki/Pumped-storage_hydroelectricity

Watch Video:: Pumped Energy Storage (2.29min)

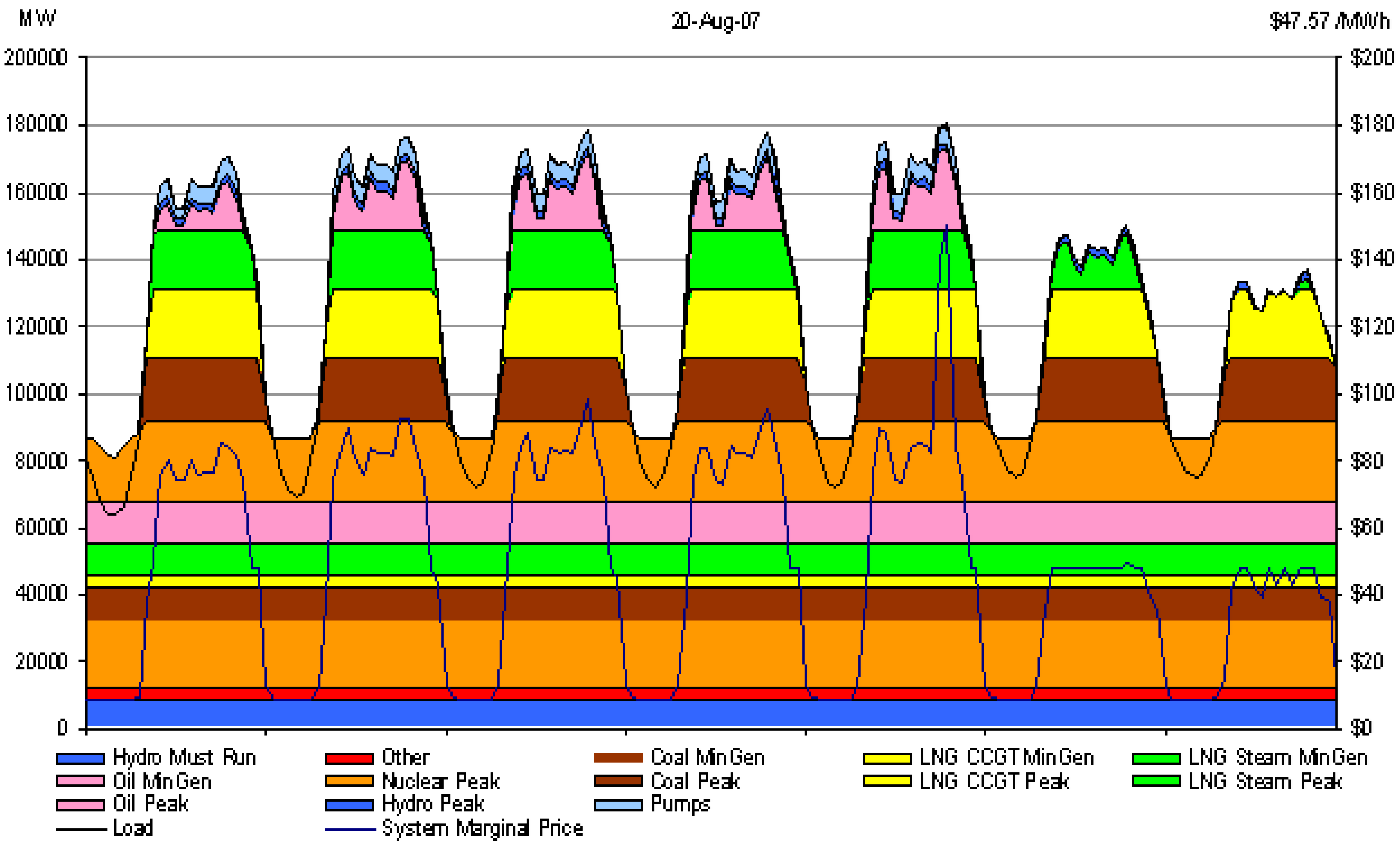
http://www.21stcentech.com/wp-content/uploads/2011/08/solar-thermal-9-storage-capacity.jpg

Watch Video: Solar thermal with storage (1.27 min)

Solar Thermal Energy With Storage



http://www.csp-world.com/news/20130201/00728/store-or-not-store-not-question-anymore



http://www.energyconsultants.com.au/images/International_Energy_Consultants_Graph3.gif

Smart Grid

- Integration of digital processing and communications with the power grid.
- Requires transformation in three areas:
  - improvement of infrastructure
  - addition of the digital layer
  - business process transformation
- Feature:
  - Improved fault detection and self-healing
  - Flexibility in enabling bidirectional flows and distributed generation
  - Efficiency
  - Load adjustment/Load balancing
  - Peak curtailment/leveling
  - time of use pricing

Smart Grid

- Smart grid is essential for allowing large amounts of renewable electricity on the grid.
- Can accommodate highly variable renewable energy sources such as solar power and wind power.
- Need to upgrade infrastructure to enable distributed generation.
- Fluctuations in distributed generation (due to weather) need to be stabilized by varying the output of the more controllable generators such as gas turbines and hydroelectric generators.

Reading: 3 Ways Wind and Solar Can Continue To Grow In a 21st-Century Grid by Dyson et al.

Bioenergy

- Bioenergy can form an important component in the overall renewable energy infrastructure.
- Especially useful for biofuel production.
- Need caution:
  - All renewable biomass cannot be used!
  - Energy crops should not be grown on food cropland.
  - Biomass for fuel should not be obtained from natural vegetation of natural habitats.
  - Agro-wastes and residues are potential fertilizers in food production. Their diversion for fuel production can deplete soil fertility.
  - Planted and sustainably managed energy forests and judicious use of agro and urban waste alone should be used for biofuel production.

Bioenergy Technologies

- Direct combustion
- Pyrolysis:
  - solid (char) fuel briquettes
  - liquid fuel (pyrolysis oil)…may need upgradation
  - Biomass gasification: synthesis gas ($CO + H_2$)
- Steam reformation: producer gas ($CO + H_2$)
- Biodiesel (transesterification of bio-derived) oils
- Biodigestion/Fermentation
  - Biogas (bio-methanation) can be sustainable since it gives energy while simultaneously yielding the waste slurry with fertilizer value.
  - Bioethanol

Watch Video: [MIT Algae Photobioreactor]() (5 min)

Innovative experimental system provides multiple benefits:

- CO_2 emission reduction
- CO_2 enhances biomass growth
- NO_x removal
- Solar Energy Utilization
- Food/Fuel production

So What Have We Understood Sofar?

- All the major conventional sources of energy have unacceptably high environmental and social impacts.
- There is an urgent need for environmentally benign alternatives.
- Solar, wind, geothermal, bioenergy and others are abundant.
- Important barriers exist:
  - Technological: Intermittence, poor predictability diffuseness and lack of large-scale storage.
  - Others: Inadequate grid infrastructure, subsidies to fossil fuels and nuclear, inadequate political will.
- A sudden transition is impossible; technologies and approaches are evolving.
- For now, some amout of conventional sources will be required to meet the demand, but they must be gradually phased out.

Energy saved is energy generated!

- Until then we must immediately and drastically reduce current energy use.
  - Managing demand is as important as managing supply.
  - Conscious consumption of direct energy and products (embodied energy) and avoiding waste.
  - Designing processes, products and our lifestyles to need less energy is crucial.

Outline

- Units and Terms
- Energy Resources, Depletion and Risks
- Environmentally Benign Forms of Energy
- Efficiency Measures
- Reduction in Consumption—Individual Perspective

Choosing Where to Implement Efficiency Measures?

- Need to analyze the energy consumption by source (coal, oil, etc.) and sector (industry, residential, etc.)
- **For max. benefit, identify the most energy-intensive end-uses and:**
  - **Replace or supplement conventional energy with economical and environmentally benign technologies (solar, wind) wherever possible.**
  - **Employ energy conservation and efficiency methods that lead to drastic advantages. e.g. heat integration.**

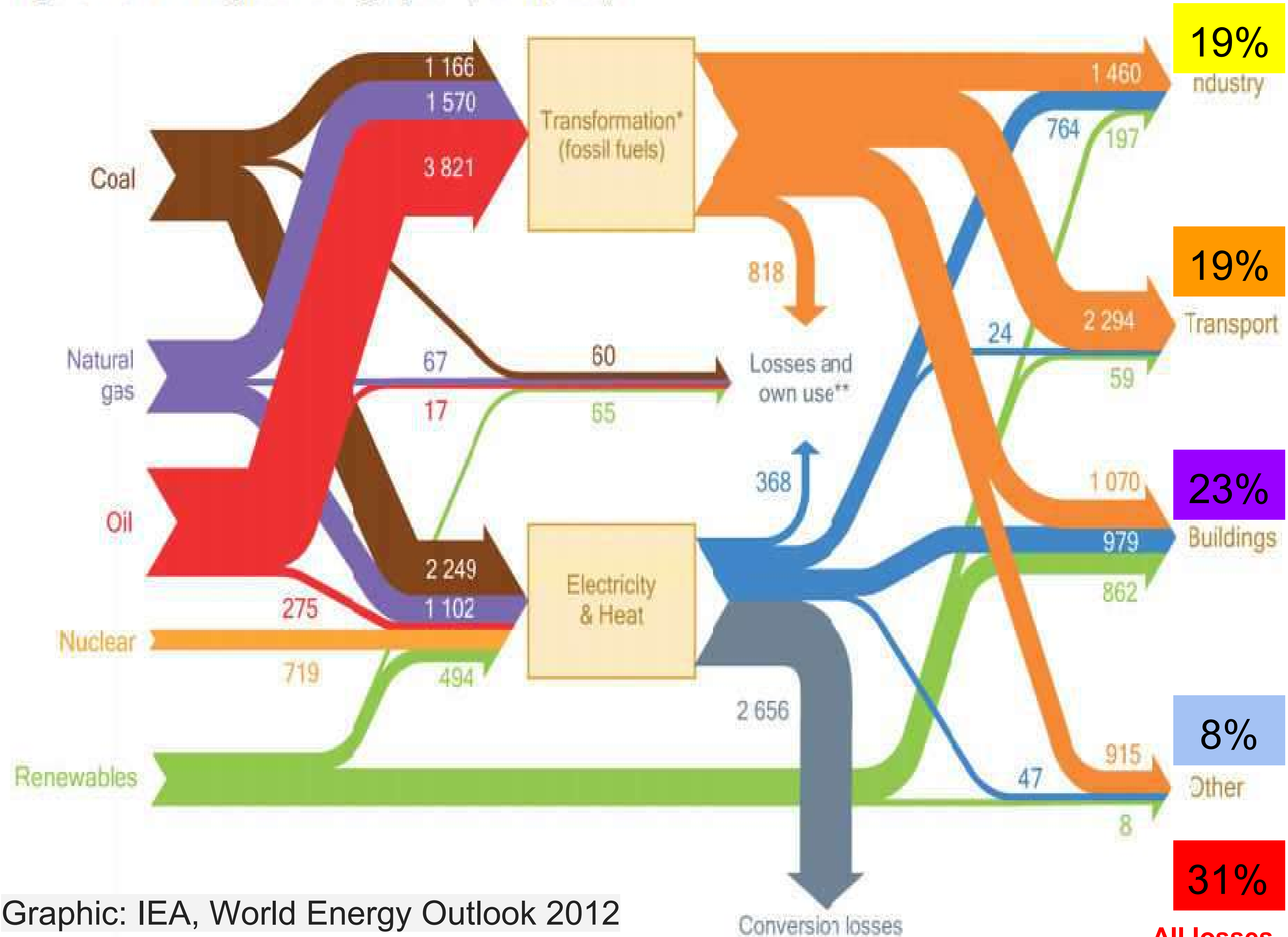
World Energy Usage: By Sector 2009

S. No.	Sector (Trillion BTU)	Primary	Total	% of Total
1.	Industrial	18571	**28199**	**29.1**
2.	Residential	6606	**21207**	**22.4**
3.	Transportation	26950	**27033**	**28.5**
4.	Commercial	3974	**18147**	**19.1**
5.	Electric Power Sector	38304		
	TOTAL		**94578**	**100**

Primary energy: Energy in the form that it is first accounted for in a statistical energy balance, before any transformation to secondary or tertiary forms of energy. For example, coal can be converted to synthetic gas, which can be converted to electricity; in this example, coal is primary energy, synthetic gas is secondary energy, and electricity is tertiary energy.

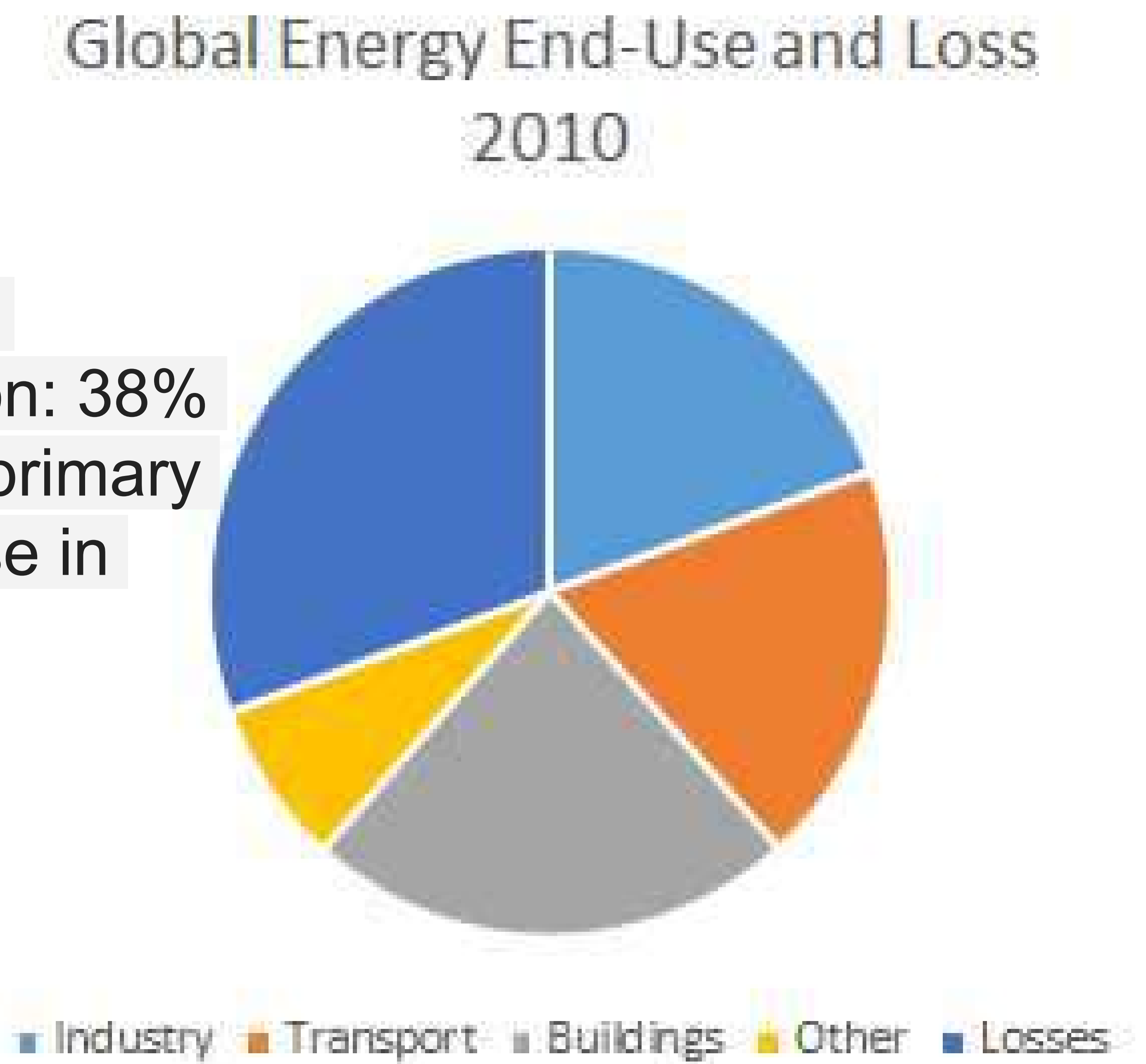
http://tonto.eia.doe.gov/merquery/mer_data.asp?table=T02.01

Figure 2.8 ▷ The global energy system, 2010 (Mtoe)



Graphic: IEA, World Energy Outlook 2012

Electricity Generation: 38% of global primary energy use in 2010



Based on: IEA, World Energy Outlook 2012

Energy in everything we buy

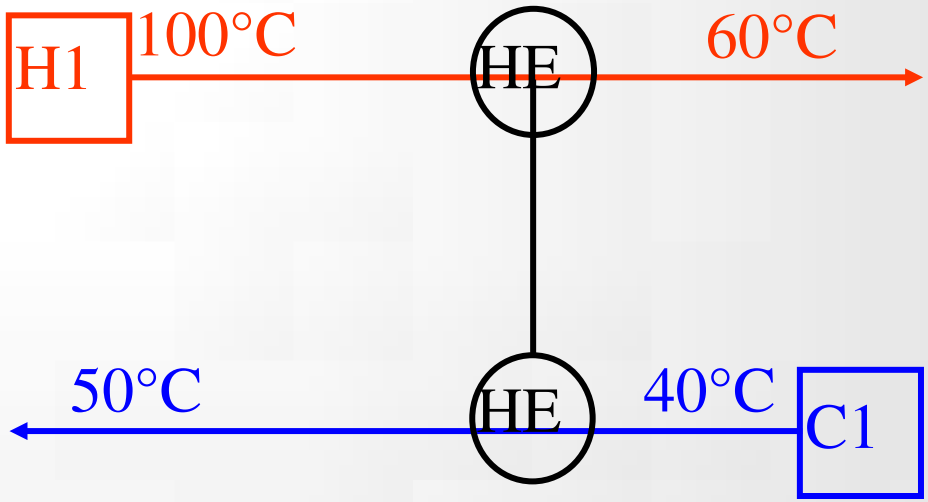
- Industry is the largest energy-consuming sector.
- So, industry must be the focus of energy conservation efforts.
  - Manufacturing our vehicles, buildings, appliances, and even our food and clothes.
  - **Embodied energy**: energy invested in a particular thing during its lifetime, from cradle to grave.
- Simply buy less and save energy!
  - Buy products with low embodied energy, high durability and only when necessary.
  - Reuse or recycle old products.

- But the manufacturing industry is essential and must go on....
- So, let's see how to reduce industry's energy use.
- Which are the most energy-intensive industries?
  - Process industries

Solar Energy for Heating/Cooling in the Process Industry

- Solar thermal energy is a mature and cost-competitive technology
- Steam generation or process heating using concentrating solar technology
- Will require a backup conventional heating module due to intermittence of solar energy.
- Solar energy for cooling can be a viable option. Two approaches:
  - Pair a photovoltaic array with a standard compression cycle based chillers.
  - Pair a solar thermal collector with an absorption chiller

Heat Integration

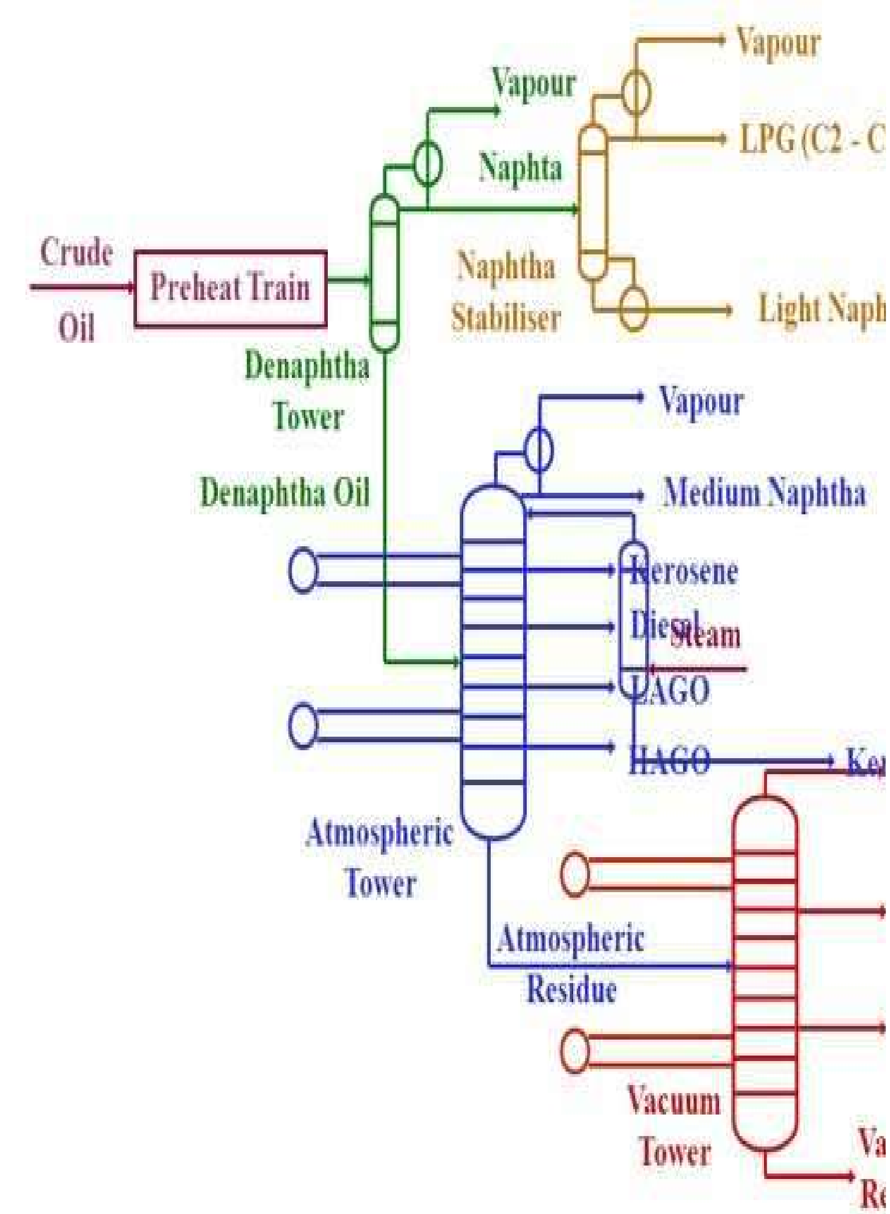


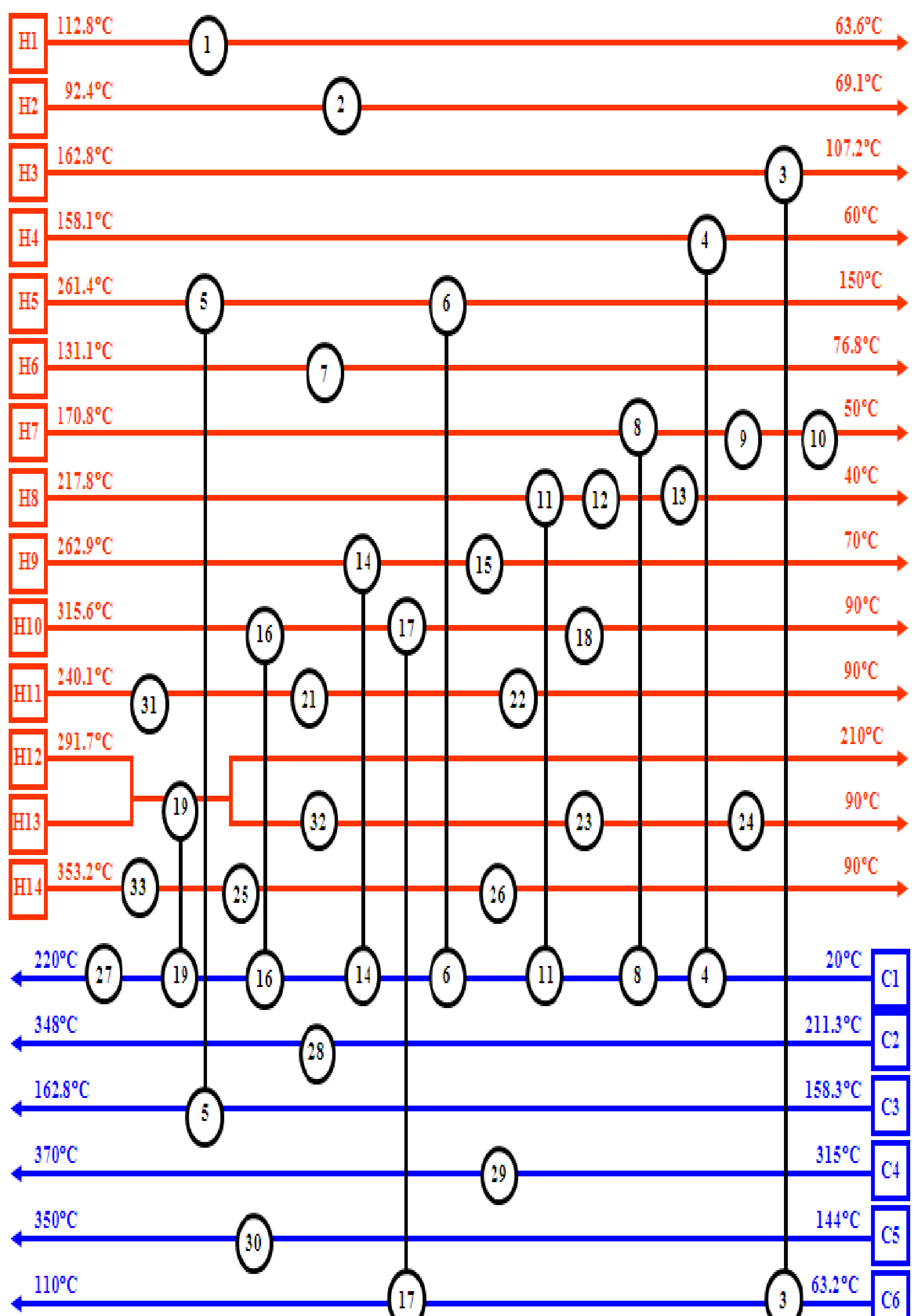
- Using the waste (or excess) heat from one product stream to heat another stream.
- HE is a heat exchanger.

Heat Integration

- Typical energy saving 15 – 45 %
- Very general – easily applicable in Power generation, Oil refining, Petrochemicals, Food and Drink Industry, Pulp & Paper, hospitals etc.
- Typical pay-back periods from a few weeks to 16 months (decision made by the client)
- Considerably contributes to Emissions Reduction including CO_2

http://www.google.com/url?sa=t&source=web&cd=2&ved=0CB0QFjAB&url=http%3A%2F%2Fwww.cpi.umist.ac.uk%2Feminent%2FConfidential%2Fmeeting%2FRigaMeeting%2FRiga%2520Workshop%2FMarch%252008%2520Jiri%2520Klemes.ppt&ei=0shkTI6tJM-jcdGf8N4K&usg=AFQjCNHWPipjaJj_Uy4LGn57slZj3-fnZQ&sig2=KOve0TJ9NsWdy_p-O2li2A





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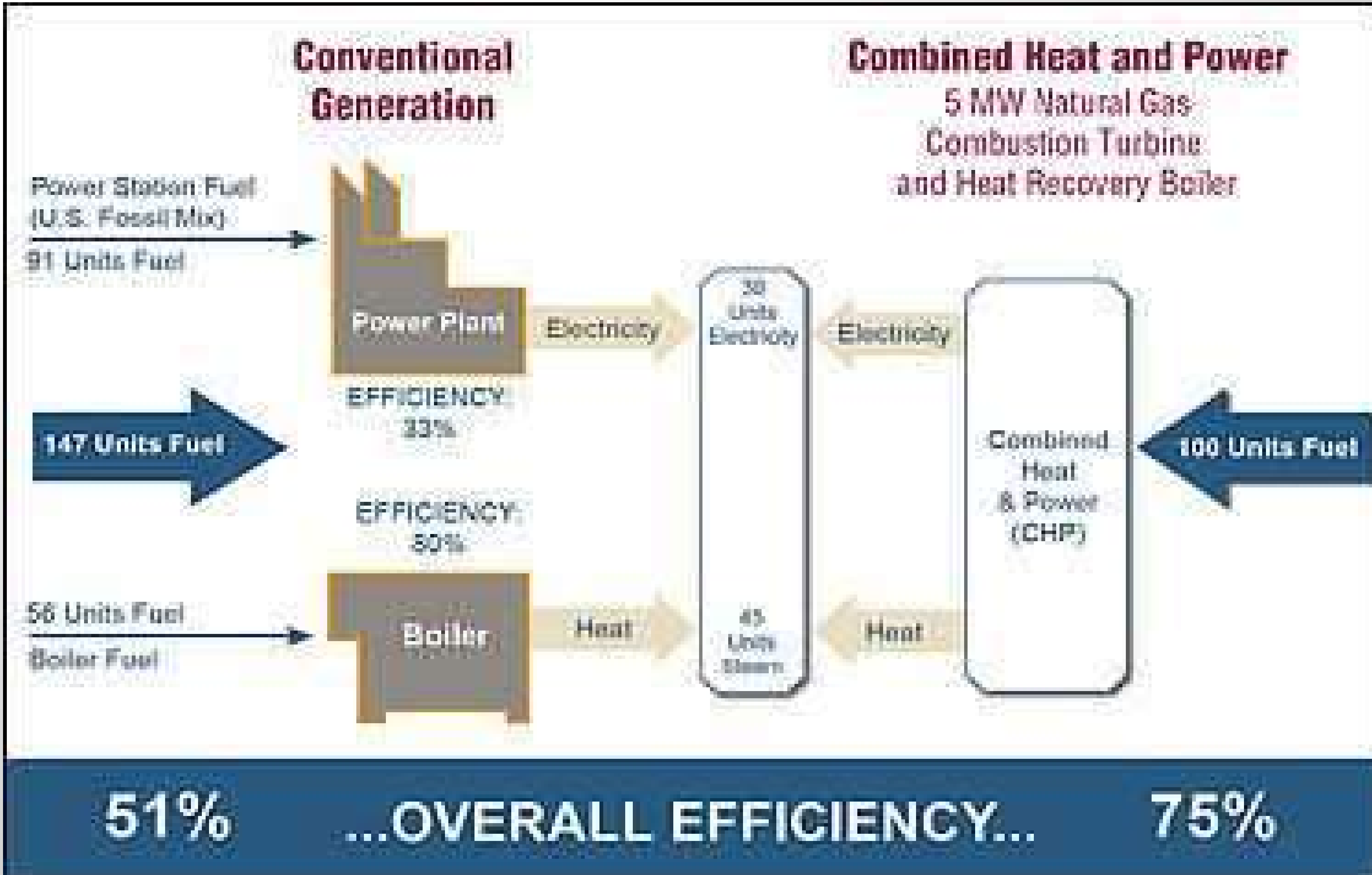
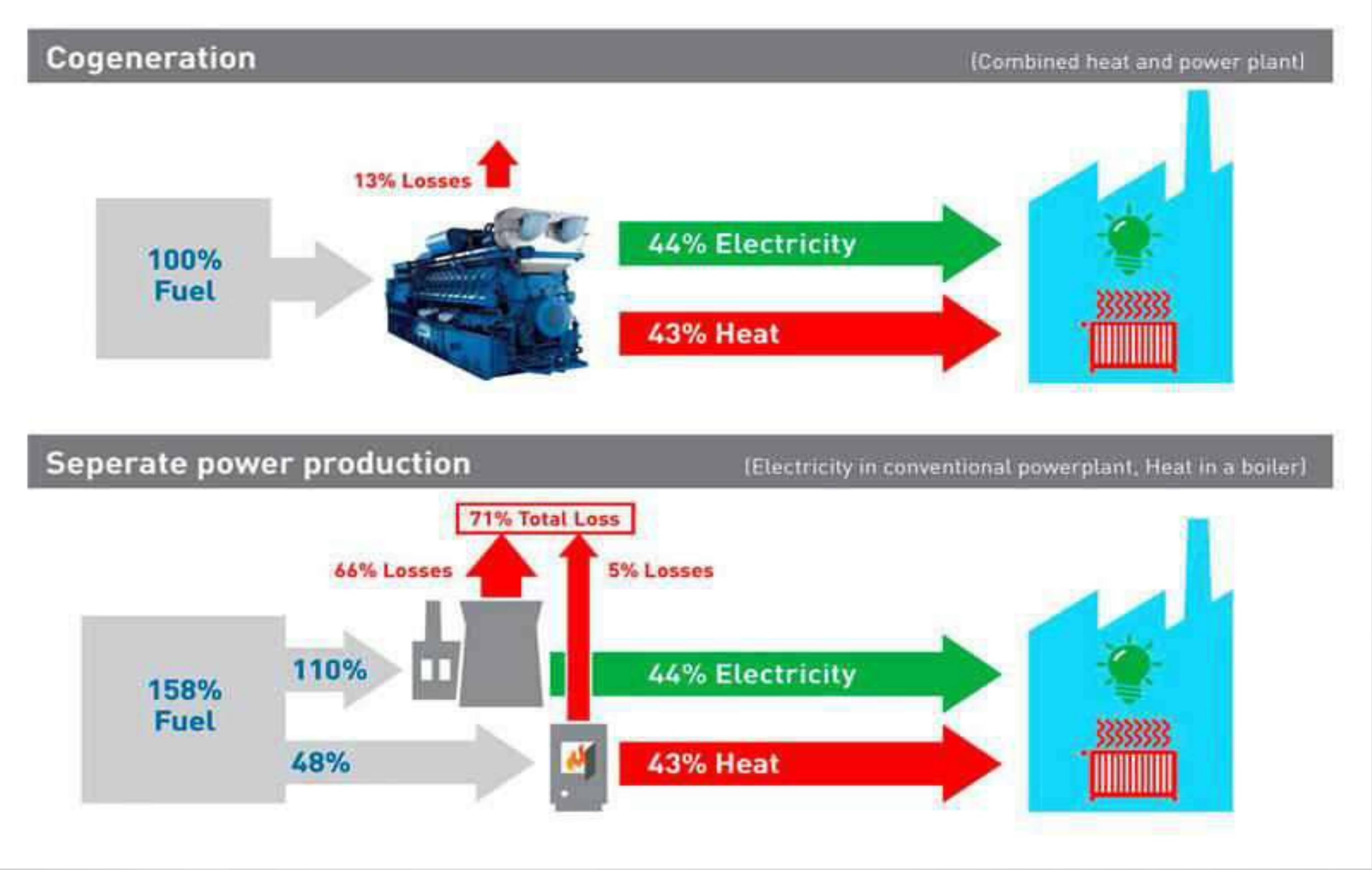
dUMzoKsL3rQeN1YDICQ&usg=AFQjCNHWPipjaJj_Uy4LGn57slZj3-fnZQ

CHP

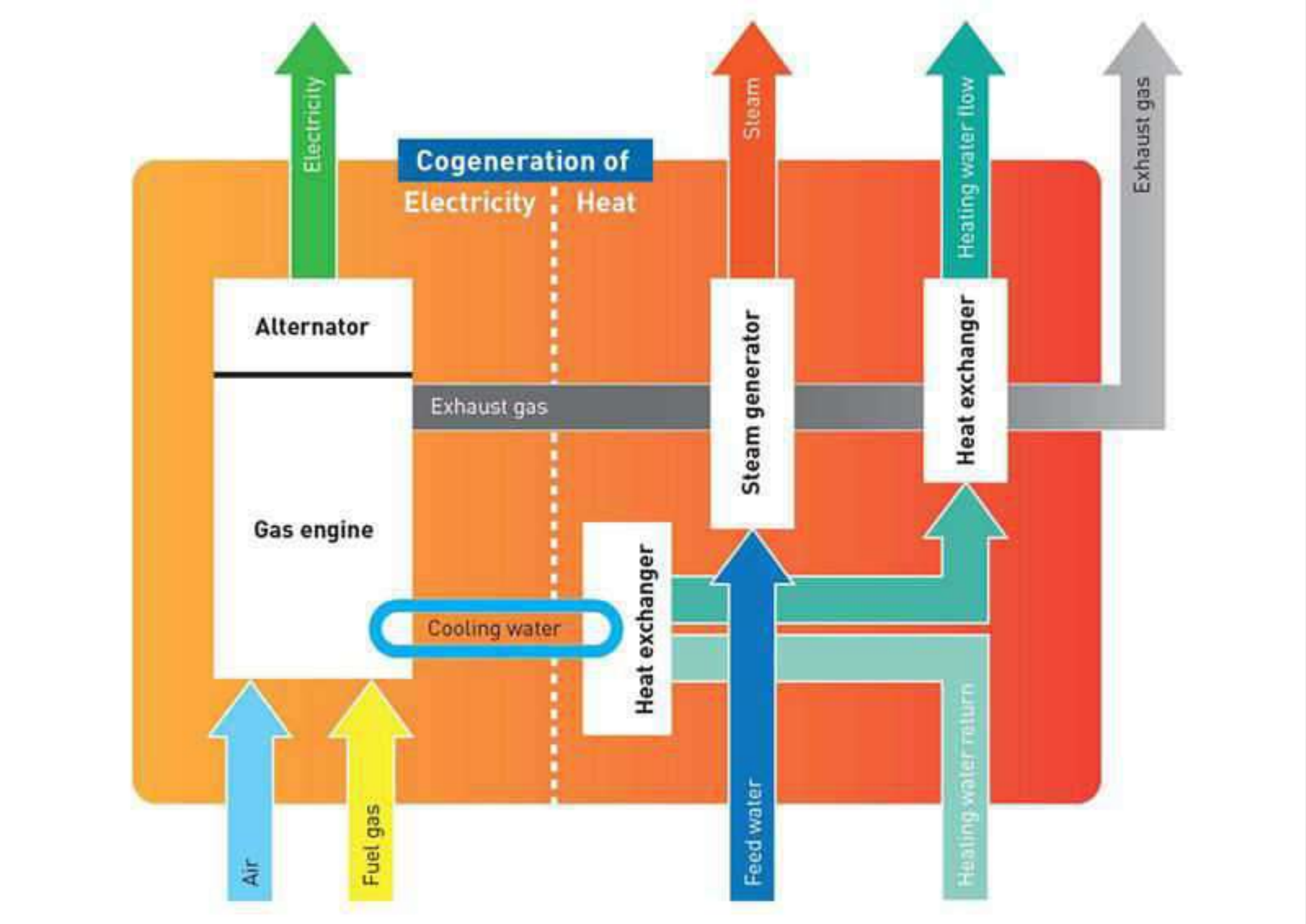

Conventional Generation
Combined Heat and Power
5 MW Natural Gas Combustion Turbine and Heat Recovery Boiler
Power Station Fuel (U.S. Fossil Mix)
91 Units Fuel
Power Plant
Electricity
30 Units Electricity
Electricity
EFFICIENCY: 33%
147 Units Fuel
Combined Heat & Power (CHP)
100 Units Fuel
EFFICIENCY: 80%
56 Units Fuel
Boiler Fuel
Boiler
Heat
45 Units Steam
Heat
51%
...OVERALL EFFICIENCY...
75%

CHP



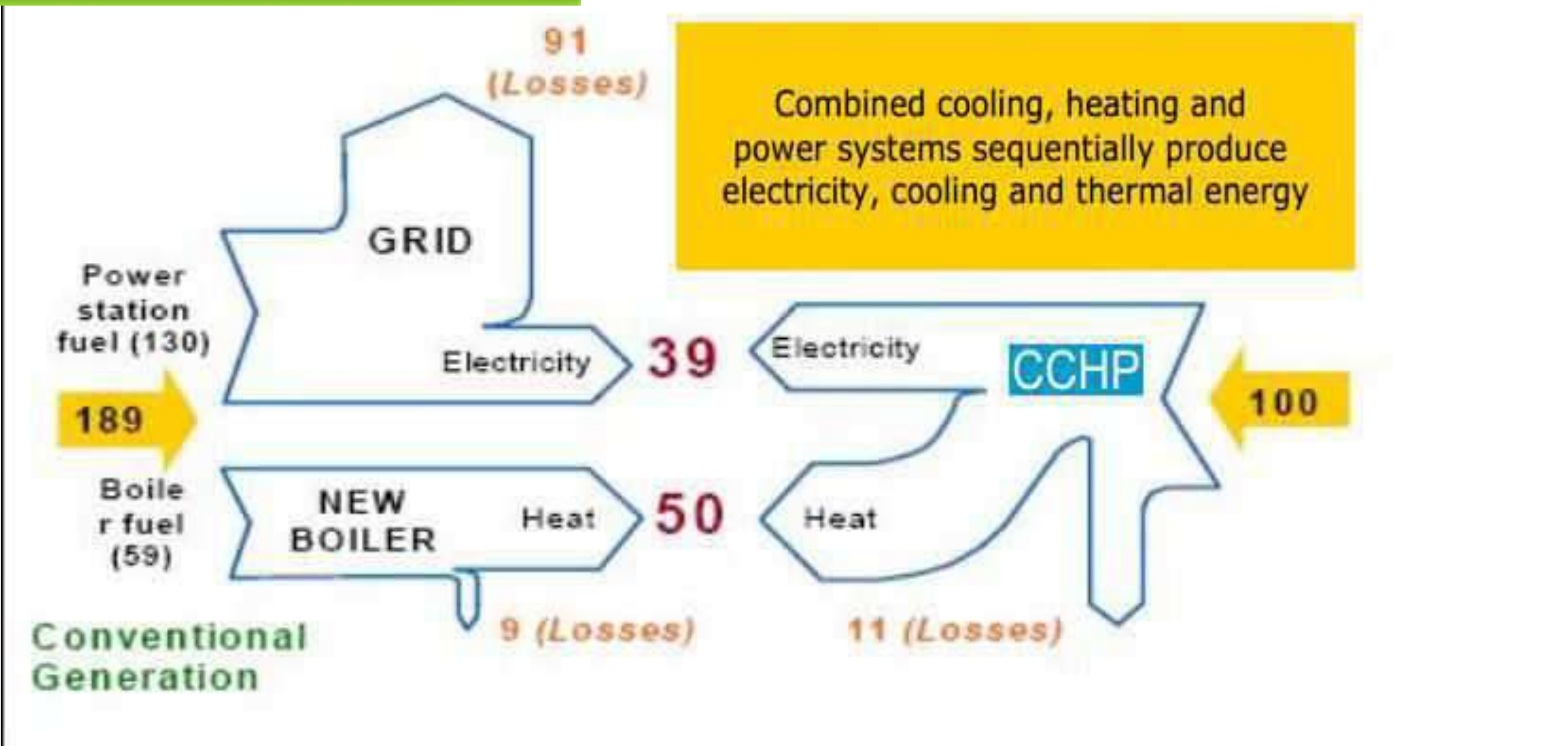
http://www.mwm.net/mwm-chp-gas-engines-gensets-cogeneration/mwm-competencies/cogeneration-trigeneration-plants/

Working of CHP



http://www.mwm.net/mwm-chp-gas-engines-gensets-cogeneration/mwm-competencies/cogeneration-trigeneration-plants/

CCHP comparison

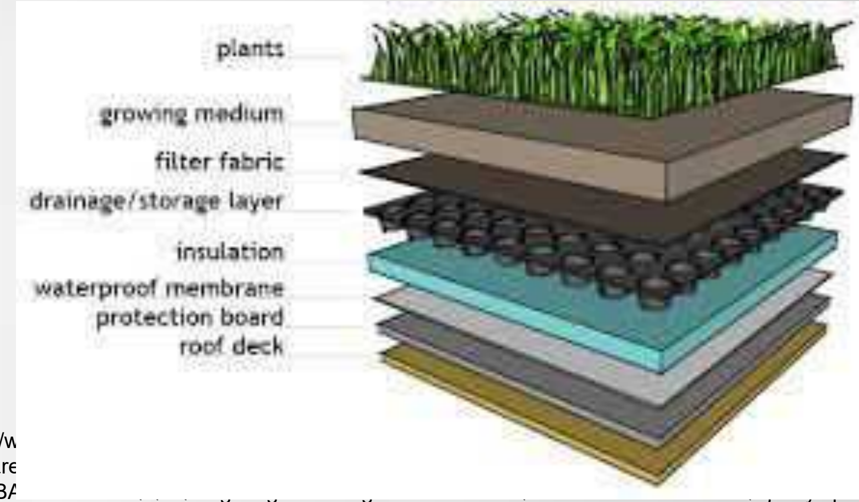


There are many ways to basically reduce our domestic energy use.

One such is green roofs:

- Reduced building heat gain.
- Evaporative cooling
- Food production
- Carbon absorption
- Possibilities for greywater recycling

Green Roofs



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green-roof-and-what-does-it-do%252F%3B750%3B514

[Earthships 101 part I](#) (5.21 min)
[Earthships 101 part II](#)(6.47min)

Outline

- Units and Terms
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- Efficiency Measures
- Reduction in Consumption—Individual Perspective

What Can Chemical Engineers Do?

- Industrial Symbiosis
- Process Integration, Pinch Technology
- Cogeneration: CHP, CCHP
- Heat Integration, Waste Heat Recovery
- Pyrolysis: gasification, liquid fuel, biomass utilization, plastic waste-to-energy, etc.
- Biomethanation (biogas)
- Biofuels
- Green Chemistry
- Plastics recycling
- Natural polymers and composites
- Environmental remediation, Waste treatment

What Can Mechanical Engineers Do?

- Cogeneration: CHP, CCHP
- Heat Integration, Waste Heat Recovery
- Industrial Symbiosis Networks
- Automotive efficiency improvement
  - Use engine waste heat for air conditioner (absorption chiller)
  - Convert engine waste heat to electricity (thermoelectric devices) and change battery.

What Can Materials Scientists Do?

- Photovoltaics:
  - organic photovoltaics
  - semiconductors, quantum dots, etc.
  - Dyes, electrolytes,
- LEDs
- Nanostructured catalysts:
  - for degradation of toxics, gas-to-liquid,
- Ultracapacitors
- Sensors
- Fuel Cells: membranes, catalysts, etc.
- Batteries: economical, high energy and power density, low toxic, rechargeable/refurbishable?

What Can Consumers Do?

- Minimize the purchase of new appliances and gadgets, clothes, and products. Repair and reuse old ones.
- Avoid air conditioners. Prefer fans or desert coolers.
- Minimize waste of electricity by turning of lights (CFL/LED) , fans and appliances, (unplug when not in use)
- Keep computer in shutdown or hibernate modes when not in use.
- Build an ecohouse: green materials and architecture, daylighting, passive heating/cooling concepts, integrated energy systems, rainwater harvesting, water recycling, dry composting toilets, backyard/terrace/balcony food gardens

What Can Consumers Do?

- Walk or use bicycles for short distances and public transportation or two-wheelers for longer distances.
- Avoid air travel and purchasing private cars.
- Purchase essential products grown/produced in the 5, 50, 100 km radius. Low product miles and low embodied energy.
- Use cloth bags and old containers for shopping. Avoid disposable plastic bags.
- Use reusable plates, cups and silverware. Avoid paper/plastic
- Calculate your carbon and ecological footprint and try to minimize it.

What Can Consumers Do?

- Conserve LPG while cooking.
- Use solar heaters to heat water.
- Minimize the use of paper
- Adopt alternative medicines (e.g. homeopathy) for minor ailments (pharmaceutical industry consumes a lot of energy)
- Be vegetarian! Vegetarian food consumes far less water, energy and is better for your health!
- Avoid processed foods.

Environmental Science

Welcome to SVN 3E!

What is Environmental Science?

The study of how humans interact with their environment

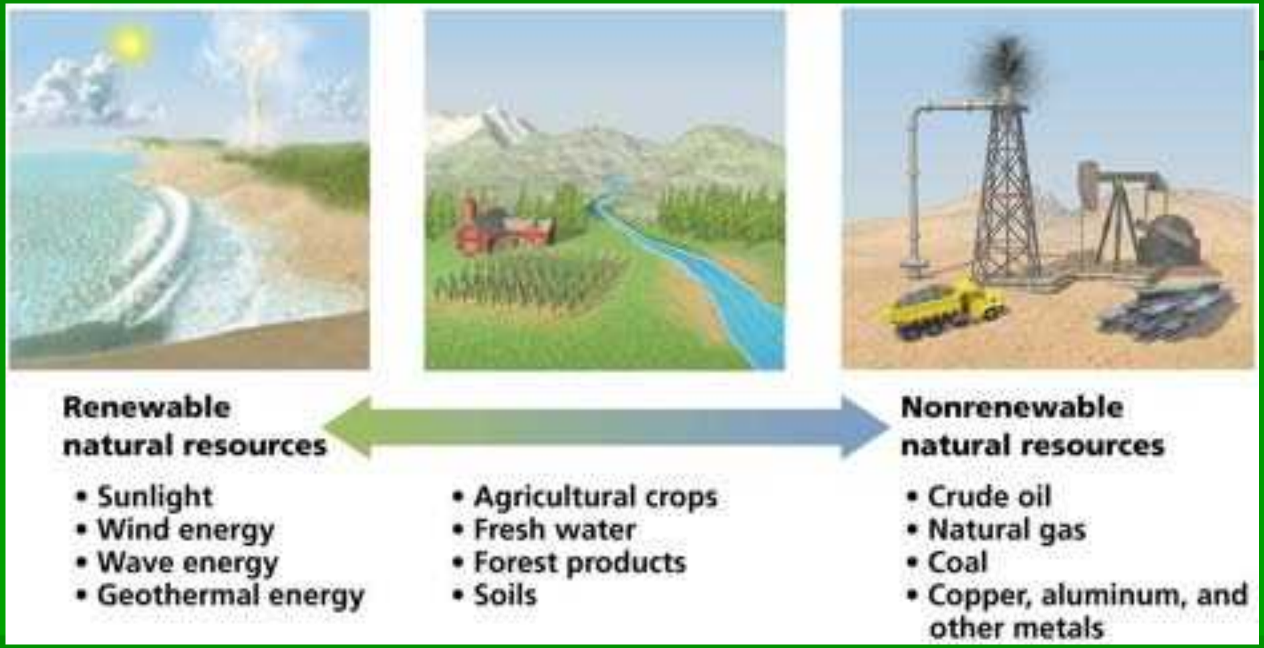
Our environment is everything that surrounds us, both natural and man-made.

Environment: the total of our surroundings

- All the things around us with which we interact:
  - Living things
    - Animals, plants, forests, fungi, etc.
  - Nonliving things
    - Continents, oceans, clouds, soil, rocks
  - Our built environment
    - Buildings, human-created living centers
  - Social relationships and institutions

Natural resources: vital to human survival

Natural resources = substances and energy sources needed for survival

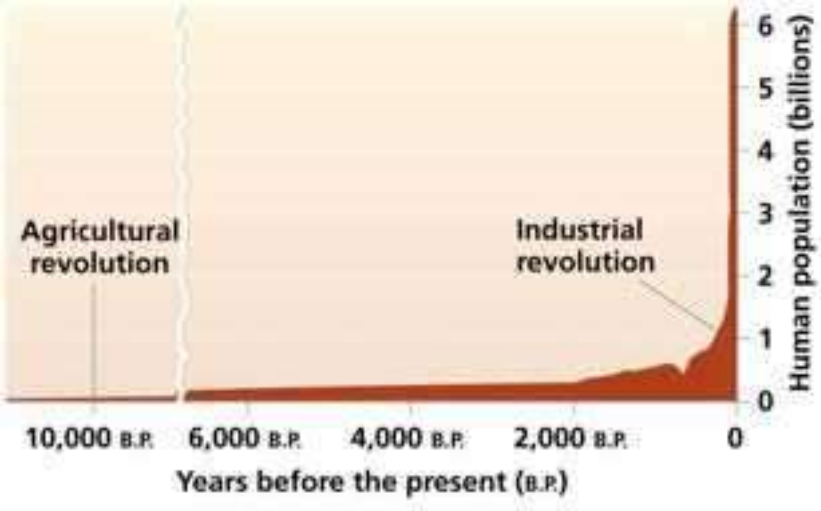


- **Renewable resources**:
  - Perpetually available: sunlight, wind, wave energy
  - Renew themselves over short periods: timber, water, soil
    - These can be destroyed
- **Nonrenewable resources**: can be depleted
  - Oil, coal, minerals

- "…the earth enables our people to survive, the environment must be respected and maintained. As long as the earth remains healthy, the people remain healthy." (*Long and Fox, 1996)*

Global human population growth

- More than 6.7 billion humans
- Why so many humans?
  - Agricultural revolution
    - Stable food supplies
  - Industrial revolution
    - Urbanized society powered by fossil fuels
    - Sanitation and medicines
    - More food



(a) World population growth


(b) Urban society

- **Human population growth exacerbates all environmental problems**
  - *The growth rate has slowed…but we still add more than 200,000 people to the planet each day* We depend completely on the environment for survival
  - Life has become more pleasant for us so far (Increased wealth, health, mobility, leisure time)
  - But…natural systems have been degraded and environmental changes threaten long-term health and survival

Brainstorm

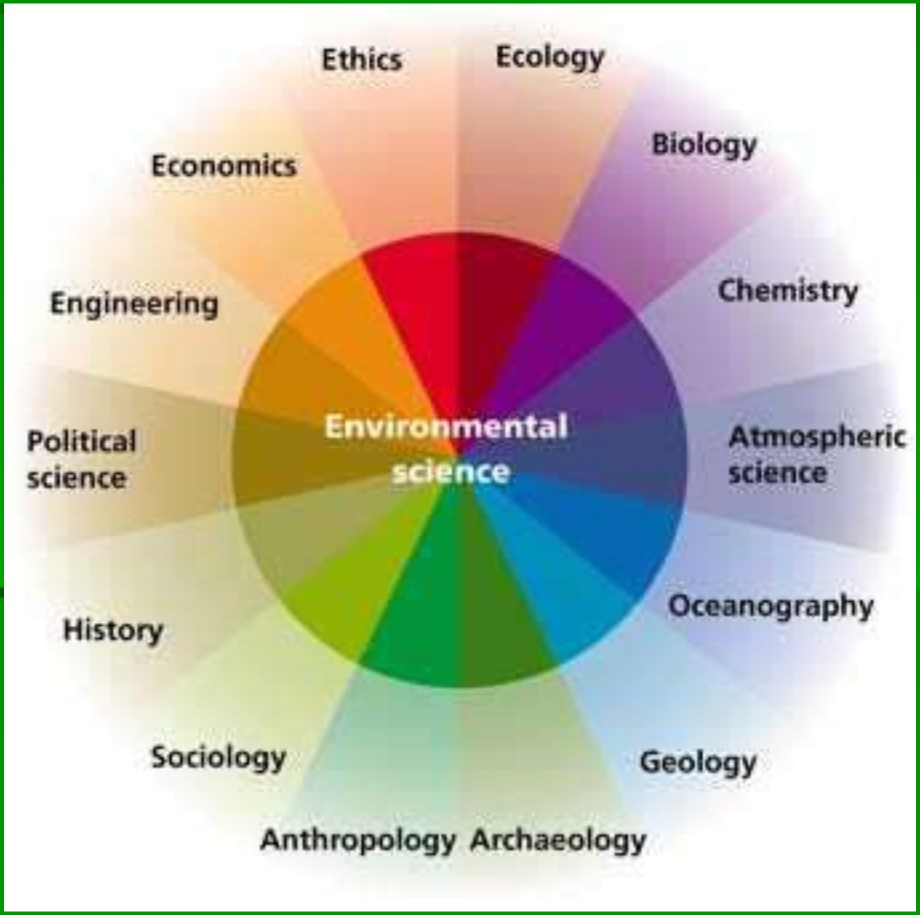
- With your partner/group, brainstorm at least 10 ways in which destruction to the environment and depletion of resources can affect our overall well being as a population

Environmental science: how does the natural world work?

Environment 🡨 impacts 🡪 Humans

- It has an applied goal: developing solutions to environmental problems

- An interdisciplinary field
  - Natural sciences: information about the world
  - Social sciences: values and human behavior, politics, economy, etc.



What is an "environmental problem"?

- The perception of what constitutes a problem varies between individuals and societies
- Ex.: DDT, a pesticide
  - In developing countries: welcome because it kills malaria-carrying mosquitoes
  - In developed countries: not welcome, due to health risks

Environmental science is not environmentalism

- **Environmental science**
  - The pursuit of knowledge about the natural world
  - Scientists try to remain objective
- **Environmentalism**
  - A social movement dedicated to protecting the natural world

The "ecological footprint"

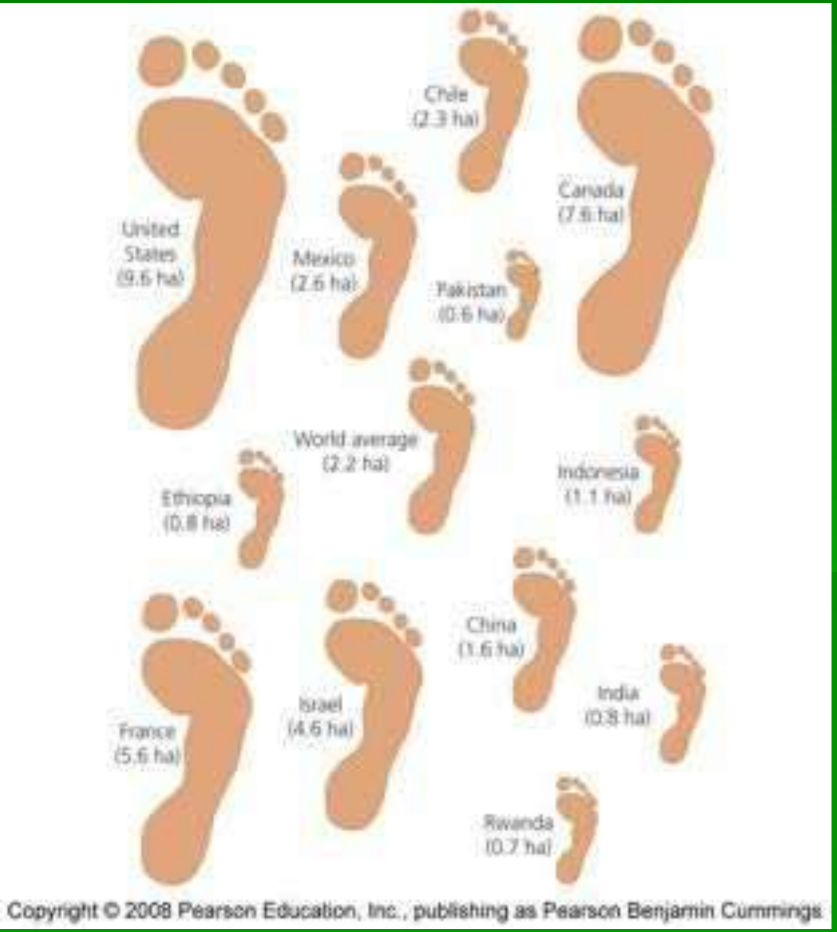
- The environmental impact of a person or population
  - Amount of biologically productive land + water

    for raw materials and to dispose/recycle waste
- **Overshoot**: humans have surpassed the Earth's capacity

We are using 30% more of the planet's resources than are available on a sustainable basis!

Ecological footprints are not all equal

- The ecological footprints of countries vary greatly
  - The U.S. footprint is almost 5 times greater than the world's average
  - Developing countries have much smaller footprints than developed countries



What are the challenges we face?

- What are the environmental issues we are facing today?
- Come up with at least 10!

We face challenges in agriculture

- Expanded food production led to increased population and consumption

  It’s one of humanity’s greatest achievements, but at an enormous environmental cost

- Nearly half of the planet’s land surface is used for agriculture
  - Chemical fertilizers
  - Pesticides
  - Erosion
  - Changed natural systems

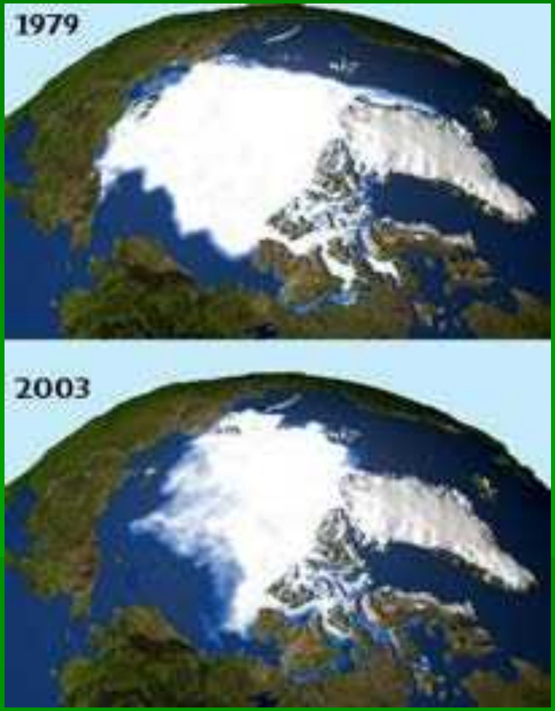
We face challenges in pollution

- Waste products and artificial chemicals used in farms, industries, and households

Each year, millions of people die from pollution

We face challenges in climate

- Scientists have firmly concluded that humans are changing the composition of the atmosphere
- The Earth's surface is warming
  - Melting glaciers
  - Rising sea levels
  - Impacted wildlife and crops
  - Increasingly destructive weather



Since the Industrial Revolution, atmospheric carbon dioxide concentrations have risen by 37%, to the highest level in 650,000 years

We face challenges in biodiversity

- Human actions have driven many species extinct, and biodiversity is declining dramatically

Biodiversity loss may be our biggest environmental problem; once a species is extinct, it is gone forever

Our energy choices will affect our future

- The lives we live today are due to fossil fuels
    - Machines
    - Chemicals
    - Transportation
    - Products

- Fossil fuels are a one-time bonanza; supplies will certainly decline

We have used up ½ of the world's oil supplies; how will we handle this imminent fossil fuel shortage?

Sustainable solutions exist

- We must develop solutions that protect both our quality of life and the environment
- Organic agriculture
- Technology
  - Reduces pollution
- Biodiversity
  - Protect species
- Waste disposal
  - Recycling
- Alternative fuels

Are things getting better or worse?

- Many people think environmental conditions are better (Human ingenuity will solve any problem)
- Some think things are much worse in the world (predict doom and disaster)
- How can you decide who is correct?
  - Are the impacts limited to humans, or are other organisms or systems involved?
  - Are the proponents thinking in the long or short term?
  - Are they considering all costs and benefits?

Sustainability: a goal for the future

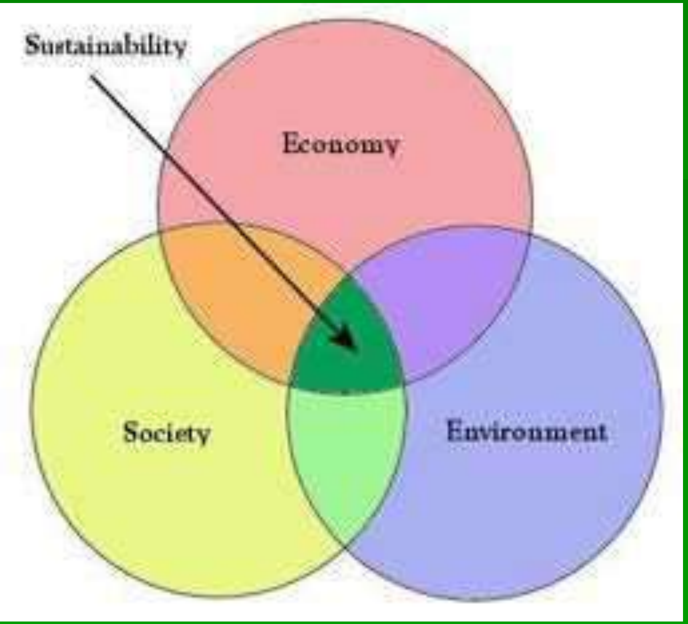
- How can humans live within the planet's means?

- **Sustainability**
  - Leaves future generations with a rich and full Earth
  - Conserves the Earth's natural resources
  - Maintains fully functioning ecological systems

- **Sustainable development**: the use of resources to satisfy current needs without compromising future availability of resources

Will we develop in a sustainable way?

- The **triple bottom line**: sustainable solutions that meet
  - Environmental goals
  - Economic goals
  - Social goals



- Requires that humans apply knowledge from the sciences to
  - Limit environmental impacts
  - Maintain functioning ecological systems

Conclusion

- Environmental science helps us understand our relationship with the environment and informs our attempts to solve and prevent problems.
- Solving environmental problems can move us towards health, longevity, peace and prosperity
- Environmental science can help us find balanced solutions to environmental problems

Introduction

ENV300 Environmental Science and Sustainability

Outline

- The Nurturing Biosphere
- Well-Being and Resource Consumption
- Present Unsustainability
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Gaia Theory

- By James Lovelock. Gaia: Greek Earth Goddess
- Earth with all intricate and interacting systems is like a Super-Organism
- Self regulation: chemistry of oceans, atmosphere, temperature, living beings
- It appears as if Earth had a purpose...to nurture life and maintain life-friendly conditions.
- This perspective brings a new awareness that can enable further evolution of humanity's understanding of Nature and interactions with it:
  - When all systems in nature work in order to nurture us, it is in our best interest to design our activities so as to be in harmony with it.
  - This idea can be the foundation of all future development.

Watch Video: How Wolves Change Rivers (5)

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Consumption, Sustainability and Wellbeing

- Humans are the beneficiaries of this dynamic, evolving, nurturing biosphere, which is our HOME.
- It sustains us: providing resources for our consumption.
- In this beautiful HOME, we would like to survive and achieve well-being into the indefinite future--SUSTAINABILITY.
- But our consumption is often continued far beyond survival--OVERCONSUMPTION.
- Overconsumption leads to very little improvement in well-being.
- But it damages the environment and reduces well-being for others and future generations...UNSUSTAINABILITY

Consumption, Sustainability and Wellbeing

- Human well-being is influenced by factors other than consumption
  - External: family, friends, education, position in society
  - Internal: identification and fulfillment of one’s purpose in life, realization of spiritual/philosophical truths.
- After consuming adequately, further improvement in well-being should be sought through other means.

Consumption, Sustainability and Wellbeing

Many thinkers of our time have realized this and are developing ways to measure well-being in relation to factors other than mere resource consumption.

- Quality of life [ref]
  - ecology, economics, politics, culture
- Human Development Index [ref]:
  - life expectancy, education, and income indices.
- Happy Planet Index[ref]:
  - Attained well-being (not necessarily material goods) per unit of extraction or imposition upon nature.
- Satisfaction with Life Index [ref]:
  - Strong correlation with health, wealth, basic education
  - Based on asking people how happy they are and social and economic development.

What are the rest of us upto?

Development, economic progress, technological progress...all for improving one's personal standard of living.

But all this happens at the cost of the environment

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Problem of Unsustainability

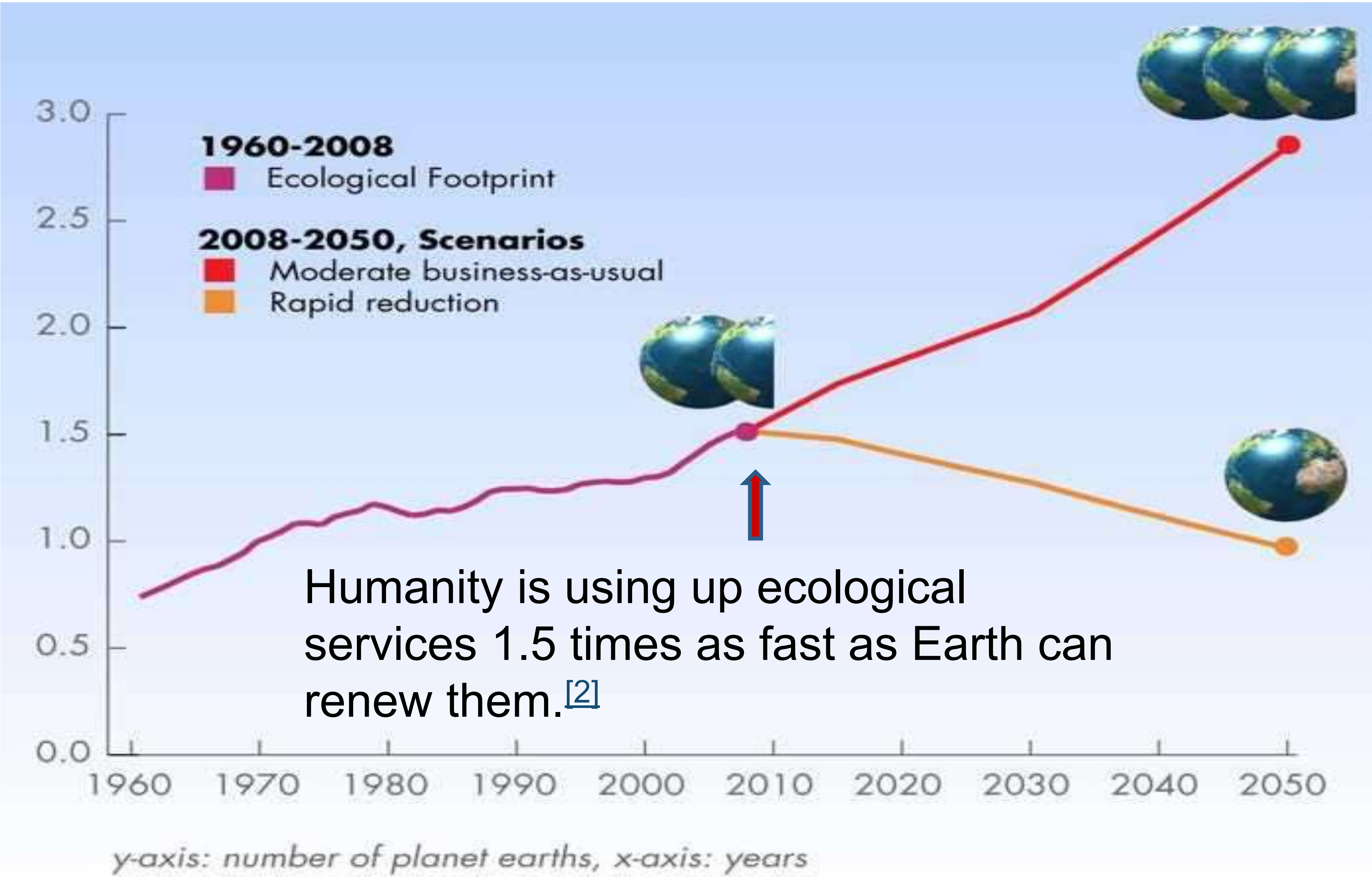
- The marvellous progress in technology and many fields, has come at a staggering cost.
- The scene of modern development is that of simultaneous crises on many fronts.
- Environmental crisis:
  - Earth-threatening environmental problems like Global Warming, Ozone depletion, Deforestation, Desertification, Loss of biodiversity, natural habitats and species, Pollution of food, water, air, land, radioactive pollution

- How do we measure our impacts on the environment?

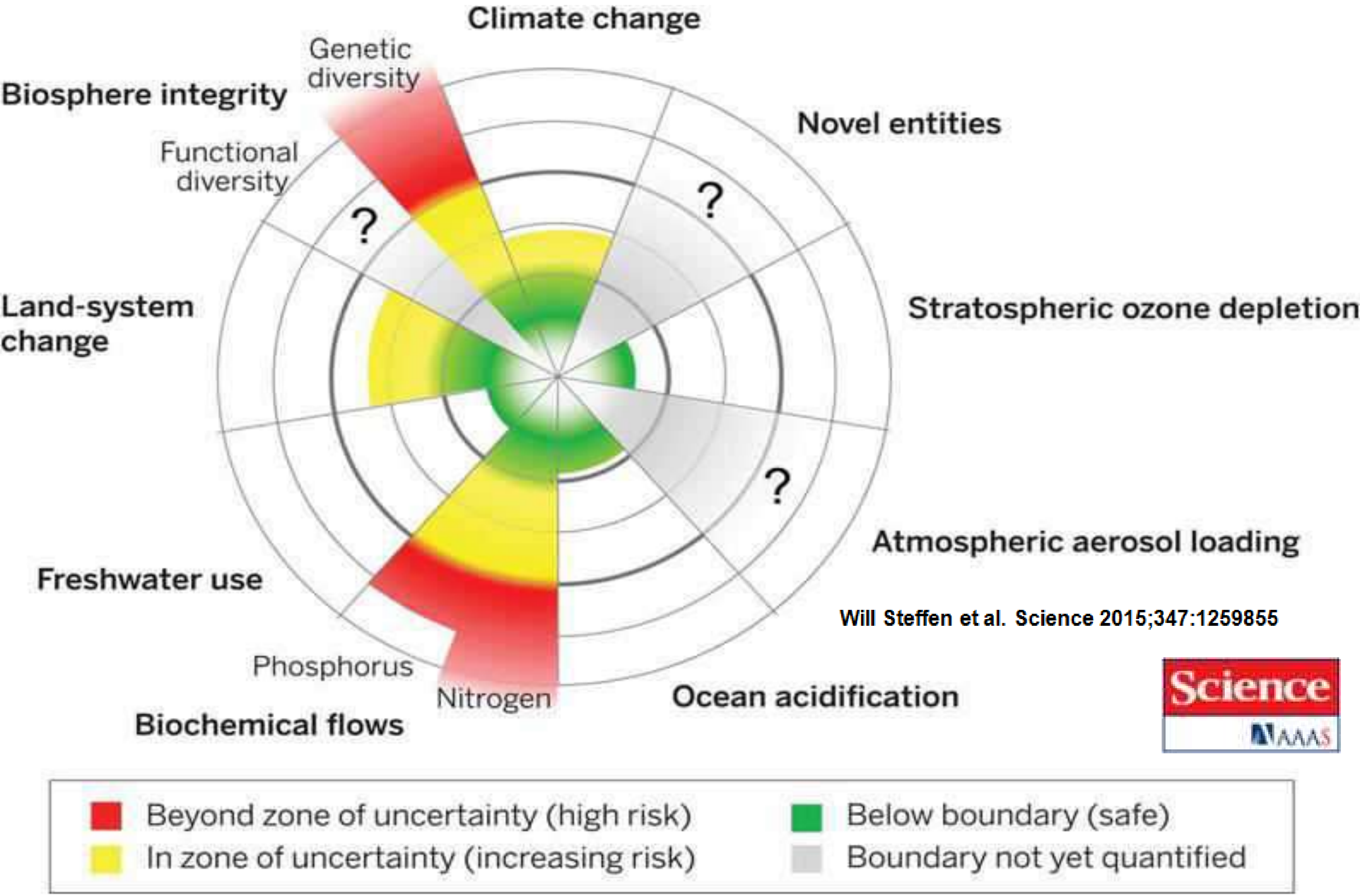
Ecological Footprint

- Resources and ecosystem services are provided by Earth through the biogeochemical cycles and the biodiverse ecosystems.
- Human activities use up or degrade Earth's resources, but Earth regenerates/recovers (biocapacity).
- **Ecological Footprint is the amount of biologically productive land and sea area needed to supply the resources a human population consumes, and to assimilate associated waste.**
- It is reported in area units.
- It attempts to quantify the human demand on the Earth's ecosystems.
- *Can be calculated for an individual, a family, an organization, a country or the entire human population on the earth.*

Humanity's Ecological Footprint



World Footprint www.footprintnetwork.org



Current status of the control variables for seven of the nine planetary boundaries.The green zone is the safe operating space, the yellow represents the zone of uncertainty (increasing risk), and the red is a high-risk zone. Published by AAAS.

Problem of Unsustainability

- Apart from the environmental crisis, we simultaneously have:
  - Social crisis:
    - War, oppression, terrorism, corruption: motivated by control over resources
    - Growing slums, degrading morality, broken families,
    - Basic needs: food, clothing and shelter—the very motivation for development—have not been satisfied.
    - Poverty and hunger.
  - Individual crisis
    - Serious health problems: Cancers, heart disease, AIDS, infectious diseases, birth defects, anxiety, stress…

Alas, development, which aims at the survival, and prosperity of humanity, ironically threatens our very existence today.

Quote for the Topic

We stand at a critical moment in Earth's history,
A time when humanity must choose its future.
As the world becomes increasingly interdependent and fragile,
the future at once holds great peril and great promise.
To move forward we must recognize that in the midst of
A magnificent diversity of cultures and life forms
We are one human family and
one Earth community with a common destiny.

Preamble to the Earth Charter (2000)

We must join together to bring forth
a sustainable global society
founded on respect for nature,
universal human rights, economic justice,
and a culture of peace.
Towards this end, it is imperative that
we, the peoples of Earth,
declare our responsibility to one another,
to the greater community of life,
and to future generations.

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Why Study This Course?

- Earth-threatening anthropogenic environmental issues
  - In developed countries, pollution and environmental damage may be less obvious
  - Shocking state of the environment in India...all around us.
- Simultaneous social problems that are deeply intertwined with environmental problems.
- You can never even begin to solve a problem unless you first understand the problem and its solution.
- The more complex the problem, the deeper your understanding should be.
- Education for Sustainability is therefore essential.

Textbooks and Notes

- Course Website: https://sites.google.com/site/amritaevs
- Course Material is provided on the website.
- Reference Books:
  - R. Rajagopalan "Environmental Studies-From Crisis to Cure", Oxford University Press.
  - G.T. Miller Jr., "Environmental Science", 11th Edition, Cenage Learning India Pvt. Ltd., 2008.
  - Benny Joseph "Environmental Studies", Tata McGraw-Hill Publishing Company Limited, 2006.

Teaching Approach

- Interactive, Open Discussions, Active Feedback
- Class participation is critical
- Medium level of difficulty
- Attendance is mandatory
- Will be required to come up and talk/present frequently.

How To Study for This Course?

- Be attentive in class.
- Participate in discussions and activities, answer questions when asked by teacher and pose questions to the teacher.
- Write notes during the lecture:
  - Lecture slides are already available to you through the course website, so the content of the slides need not be copied in notebook in class.
  - Simply write the **slide number or slide heading in the margin.**
  - Write details explained or mentioned by the instructor ***that are not indicated on the slide***.
  - Add any additional points that you notice.

How To Study for This Course?

- **Must revise everyday; study the slides and your notes together.**
  - **Write a 1-2 pg summary of each topic.**
  - **Do additional independent reading on each topic.**
  - **Independently reflect on the topic, and write down your reflections.**
- Bring difficulties to the notice of the instructor before it is too late.
- Be prepared for the next lecture (questions and surprise tests).

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What is the state of the environment?

State of the environment: Who tells us?

- Regular reports
- State of the World Report (Worldwatch Institute)
- Global Environment Outlook (UNEP)
- State of India's Environment (CSE)
- Living Planet Report (WWF)

- Other sources of reports
- World Conservation Union (IUCN)
- Earth Policy Institute

State of the environment: What are the messages?

- Thematic reports (Examples):
- World Water Development Report (UN)
- World Commission on Dams
- Intergovernmental Panel for Climate Change

- Special reports
- UN Millennium Ecosystem Assessment

Upon reading all the various reports, a common story emerges…

The story of what Man has been doing to Nature.

It is a story of many chapters…

Let's see some of them one by one.

Man first said:

Let us cut all the trees

and

remove the forests!

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Once upon a time,

about 2500 years ago, on a small island, in the Pacific, people actually cut down all the trees.

They also made…


North America
North Atlantic Ocean
Africa
North Pacific Ocean
EQUATOR
0°
Lima
South America
South Atlantic Ocean
Santiago
30°
South Pacific Ocean
90°
30°
Antarctica

Easter Island

- Colonised 2500 years ago by Polynesians
- 1400 AD: Population of 20,000
- Large stone sculptures
- Palm trees used up, none left
- No more boats, fish
- Water runoff, drought, famine
- Conflicts over resources, collapse
- 1722 AD: Dutch explorers found just 2000 famished people on barren island !

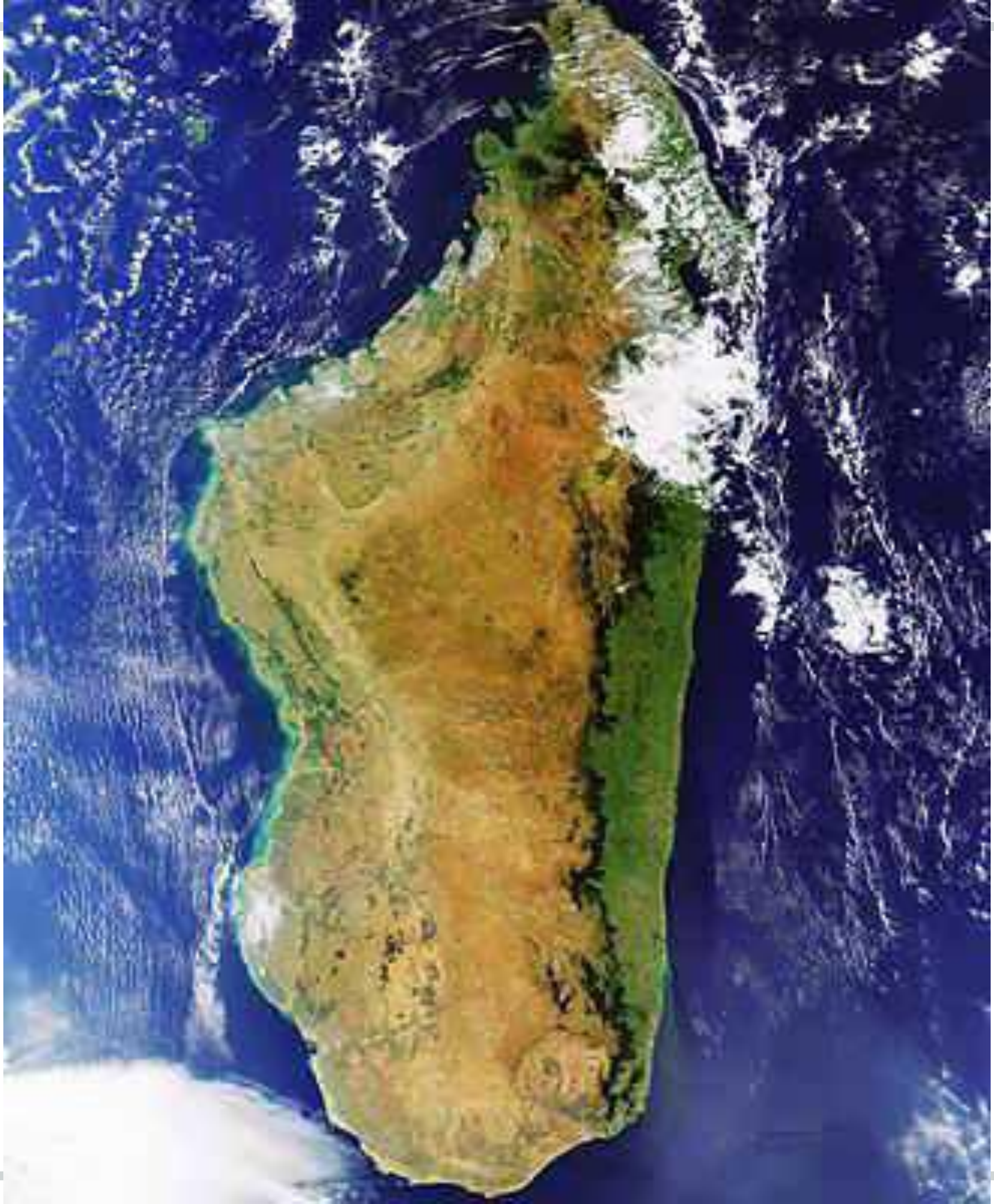
Can Easter Island happen again?

No,

Easter Island is an old story,

we are wiser today !

Are we ?




Comoros
Mayotte
Antsohimbondrona
Nosy Be
Maromokotro
Mozambique, Africa
Mahajanga
Betsiboka River
Mozambique Channel
Madagascar
Toamasina
Antananarivo
Ankaratra Mountains
N
W
E
N
Morondava
Fianarantsoa
Mananjary
Mangoky River
Mankara
Toliara
Indian Ocean
100 miles
Tolanaro
©EnchantedLearning.com

Madagascar

- 40 million years in isolation
- Astonishing biodiversity
- 85 % species endemic
- Humans arrived 1500 years ago
- 80 % of forests destroyed, soil erosion
- Most species endangered
- 50 % may go extinct by 2025

Easter Island and Madagascar

are far away,

surely it cannot happen in India!

The Himalayas

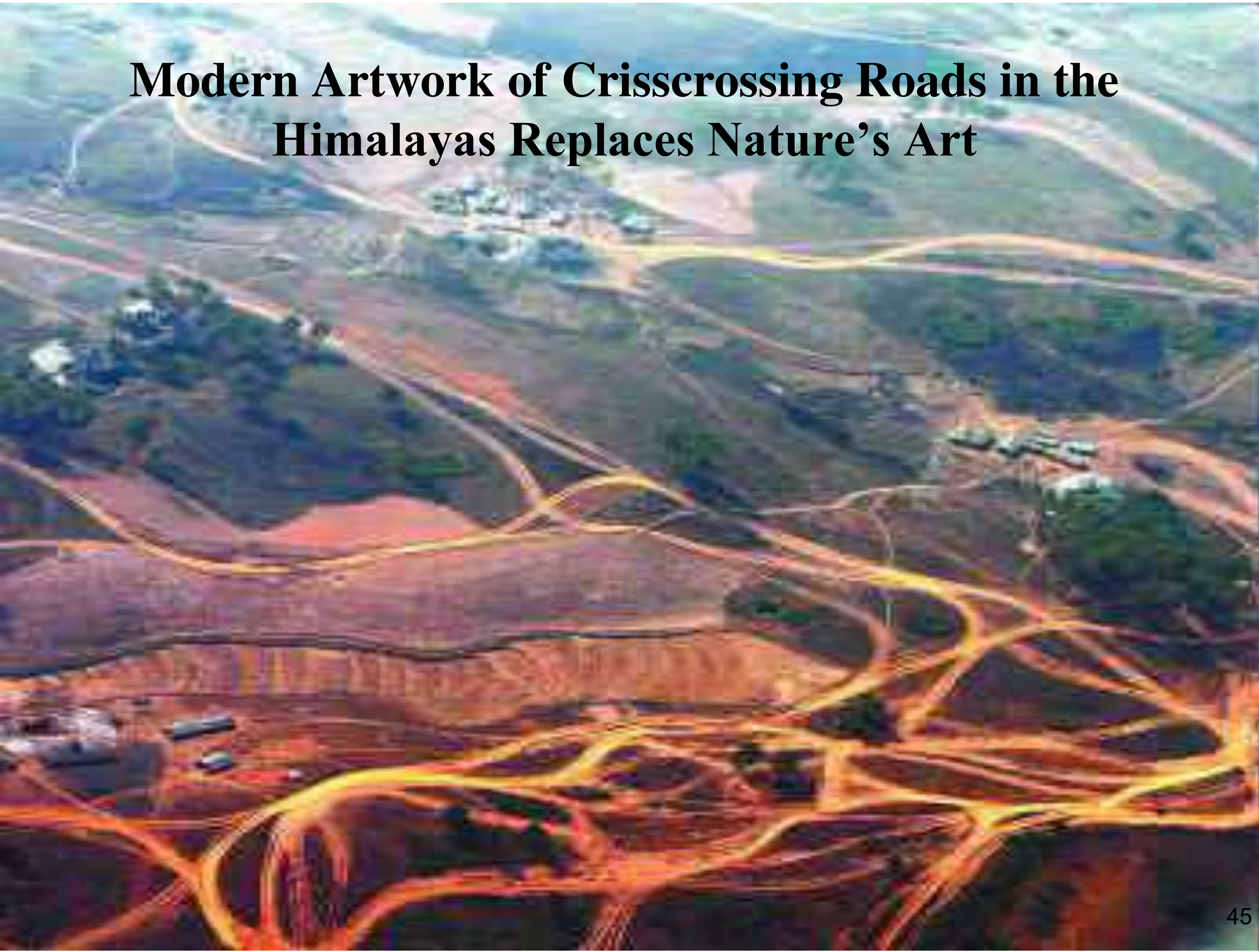
- Responsible for India's monsoon
- Source of many rivers
- Had 40 % forest cover
- Immense biodiversity
- Metal deposits
- 50 million people in the region

Himalayas laid bare: severe deforestation and denudation

The Himalayas in peril

- Deforestation:
  - Landslides, soil erosion, floods
- Projects and road building:
  - More exploitation, ecosystems affected
- Mountaineering:
  - Garbage, heavy movement, resource depletion
- GLOBAL WARMING: GLACIERS ARE MELTING

Modern Artwork of Crisscrossing Roads in the Himalayas Replaces Nature's Art



Result: The Uttarakhand Disaster

Nature avenges its exploitation

There is little doubt that the present Himalayan disaster has been triggered by natural events, but the catastrophe is man-made. **--The Hindu**

Forests

- More than 50 countries have lost between 90 and 100 per cent of their forests
- Tropical forests are being cleared at the rate of one hectare every second.

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Man felt so powerful. He thought:
Let us kill birds, tigers, elephants,
all other life forms,
and cause
the Sixth Mass Extinction of species !

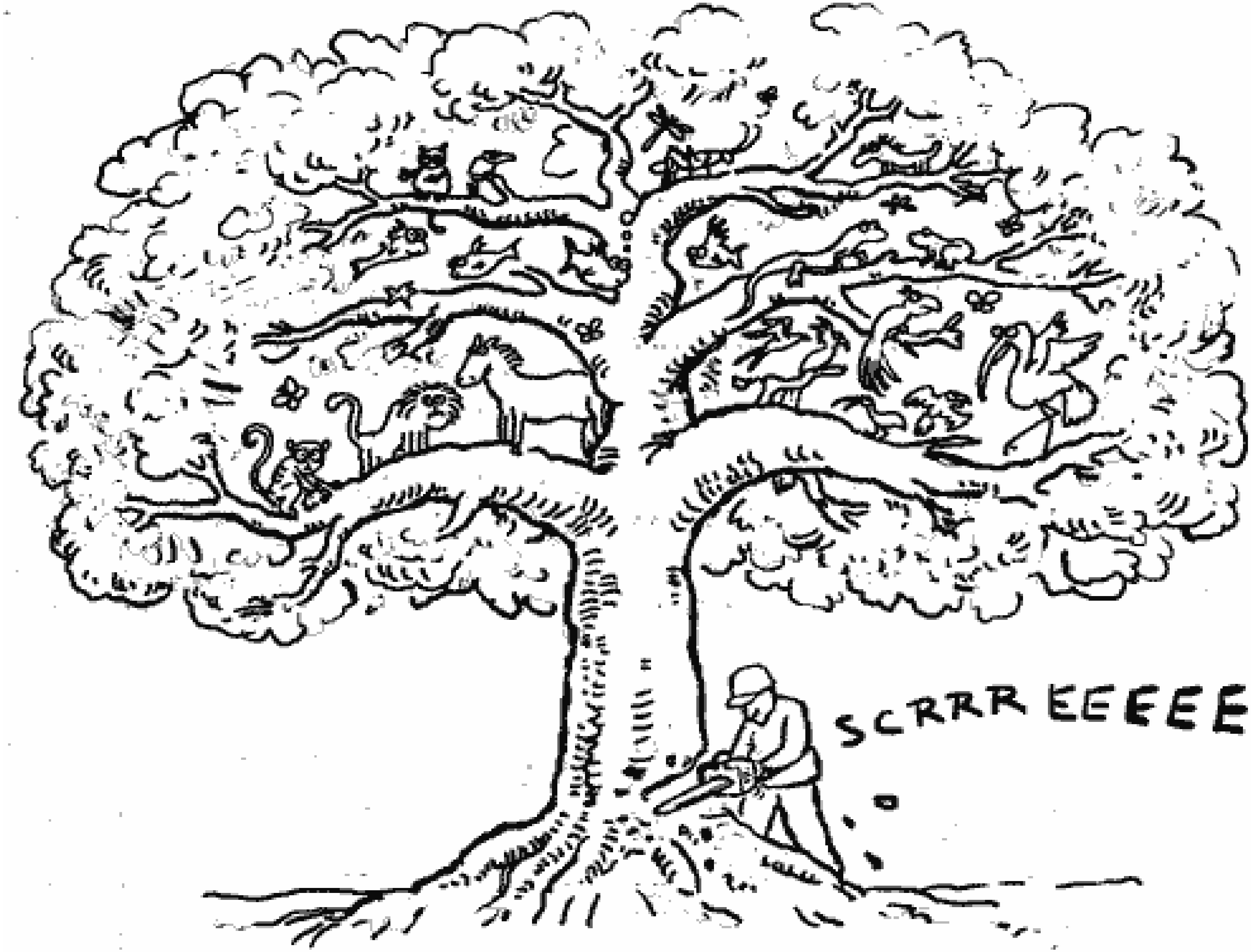
Biodiversity

World:

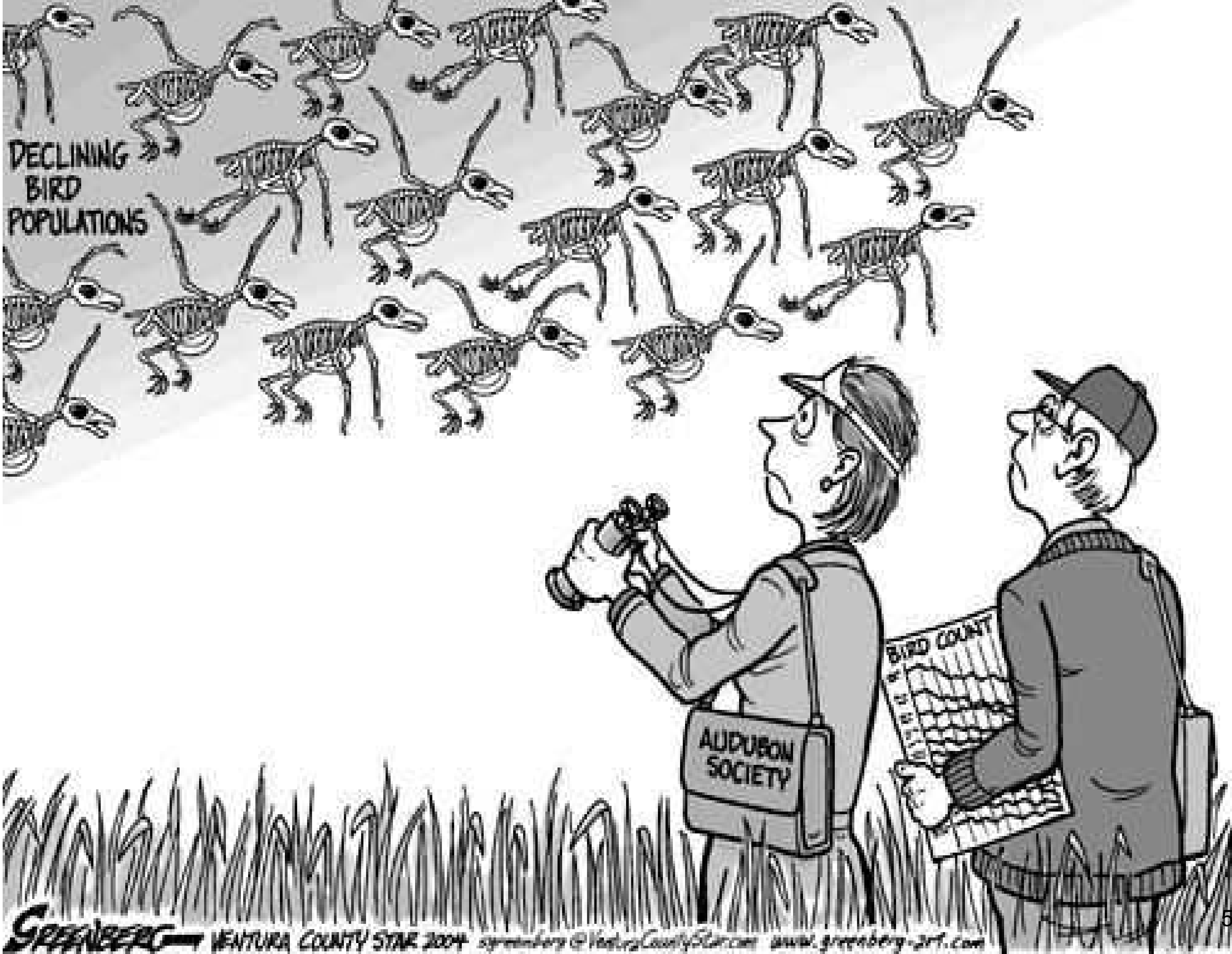
- 24% mammals, 12% birds, 25% reptiles, 30% fish threatened or endangered
  - 100-1000 times faster than natural process of extinction

India:

- > 10% flora and fauna are threatened, many on verge of extinction



THE TREE OF LIFE


DECLINING BIRD POPULATIONS
AUDUBON SOCIETY
BIRD COUNT
GREENBERG
VENTURA COUNTY STAR 2004

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Man continued:

Let us extract all the groundwater,

pollute all the waterways,

exploit the oceans and coastal space!

Water

- The per capita availability of freshwater is declining globally.
- Contaminated water remains the greatest single environmental cause of human sickness and death.
- The decline of quantity and quality of surface and groundwater is impacting aquatic ecosystems and their services.
- By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the people in the world could be subject to water stress.

Water

World:

- 80 countries of the world suffer from serious water shortages:
  - 1.5 billion people, one fourth of the population, have no access to safe drinking water.
  - Half the population lacks sanitation facilities.

India:

- No drinking water in > 60,000 villages
- Diarrhoea kills one million children per year
- 45 million affected by bad water per year


STATE OF THE WORLD'S
ENVIRONMENT
2025 AD
PLAYING
CRICKET?
COLLECTING
WATER.

Oceans, Rivers, and Fisheries

- Aquatic ecosystems continue to be heavily exploited, putting at risk sustainability of food supplies and biodiversity.
- Global marine and freshwater fish catches show large-scale declines, caused mostly by persistent overfishing.
- No fish to catch, by 2050 ?

State of the Coast

- The average population density in coastal areas is now twice as high as the global average.
- More than 100 million people live in areas no more than one metre above mean sea-level.
- 21 of the world’s 33 mega-cities are located in coastal areas, with most of them in developing countries.

State of the Coast

- Poor planning,
- the loss of key ecosystems such as wetlands, mangroves and coral reefs, and
- sea level rise due to climate change,
- are increasing the risk of flooding and reducing coastal protection from storms, tsunamis and erosion.

Coastal/Marine Degradation

World:

- Marine pollution has increased enormously.
- World fisheries have collapsed due to overexploitation and pollution.

India:

- 50% of mangroves and corals lost
- Heavy sea erosion, sea water intrusion

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Man said:

Let us be cool, use CFCs,

and

blow a big hole in the ozone layer !

Ozone Hole

- The “hole” in the stratospheric ozone layer over the Antarctic is now the largest ever.
- Due to decreased emissions of ozone depleting substances and assuming full Montreal Protocol compliance, the ozone layer is expected to recover, but not until 2060 (or even later).

"There goes another one through the hole in the Ozone."

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Man also had a great idea:

Let us create big cities

and

we can live happily !

Our Urban Future

- An Urbanizing World
- Increase in urban population:
- From 732 million in 1950
- to 3.2 billion in 2006.
- Half the world population is in cities (from 2008)
- Asia and Africa to double their urban populations to roughly 3.4 billion by 2030.

Urban Woes

- Roughly half the people in African and Asian cities lack adequate water and sanitation.
- 6 of the 10 are vulnerable to storm surges.
- Eight of the world's 10 most populous cities sit on earthquake faults
- Urban air pollution kills an estimated 800,000 people each year, roughly half of them in China
- Each year, traffic accidents kill about 1.2 million people and injure up to 50 million more.

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Then Man said:

Let us use up all the natural resources, convert them to waste,

and dump it or

pollute the air and water !

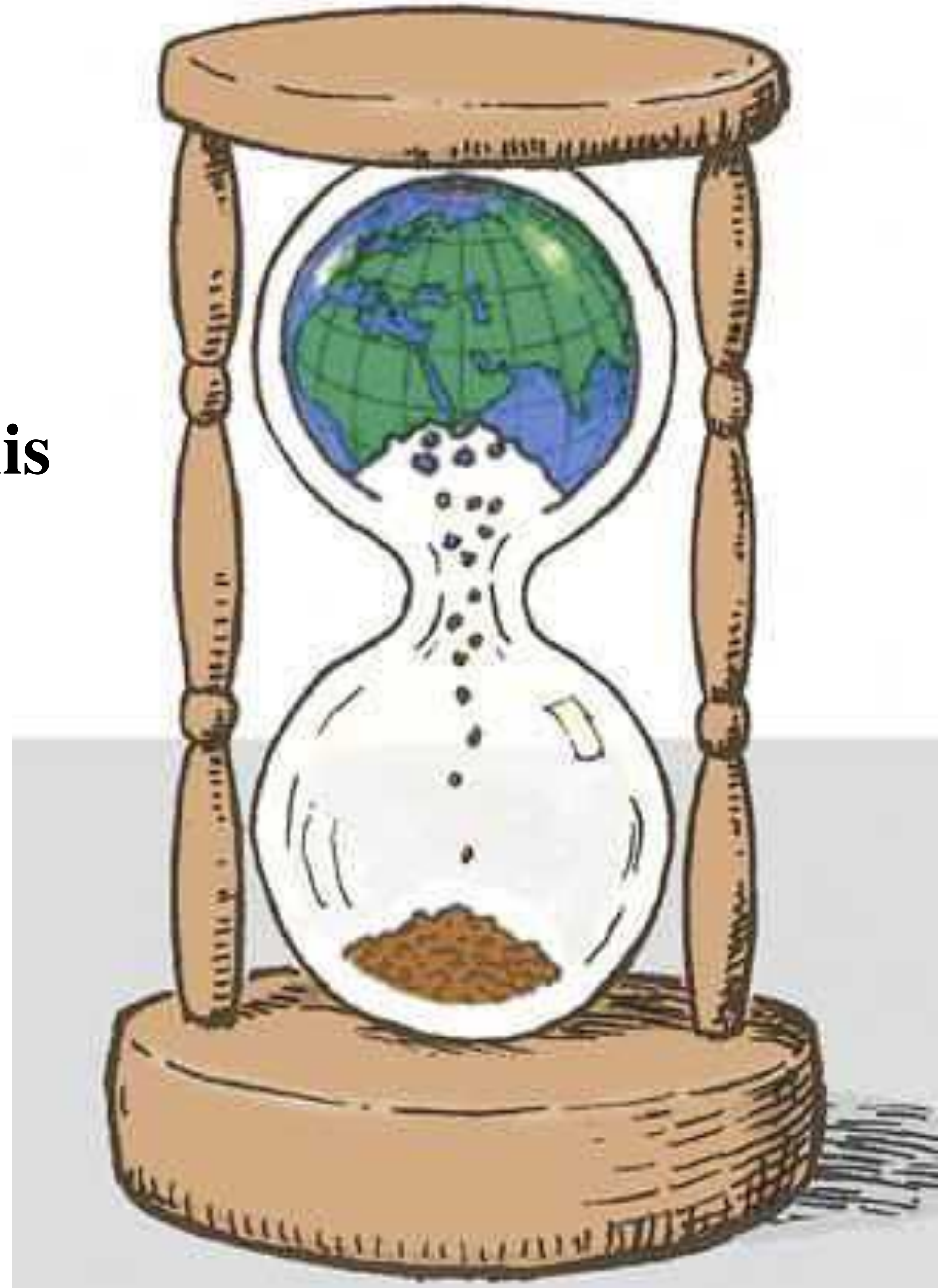

The original inhabitants of this land had a saying -
'Every time you take something from the Earth,
you must give something back.'
WASTE
DISUSED
QUARRY
KEEP OUT
LANDFILL
INC
Chris Madden

Air Pollution

- At least one billion people in the world breathe unhealthy air.
- More than 2 million people globally die prematurely every year due to outdoor and indoor air pollution.
- Although air pollution has decreased in some cities in the North, emissions are increasing in many cities of the South.
- Indoor air pollution due to the improper burning of solid biomass fuels imposes an enormous health burden.
- Indian cities among the most polluted in the world.

Can you interpret this cartoon?

Can you interpret this cartoon?



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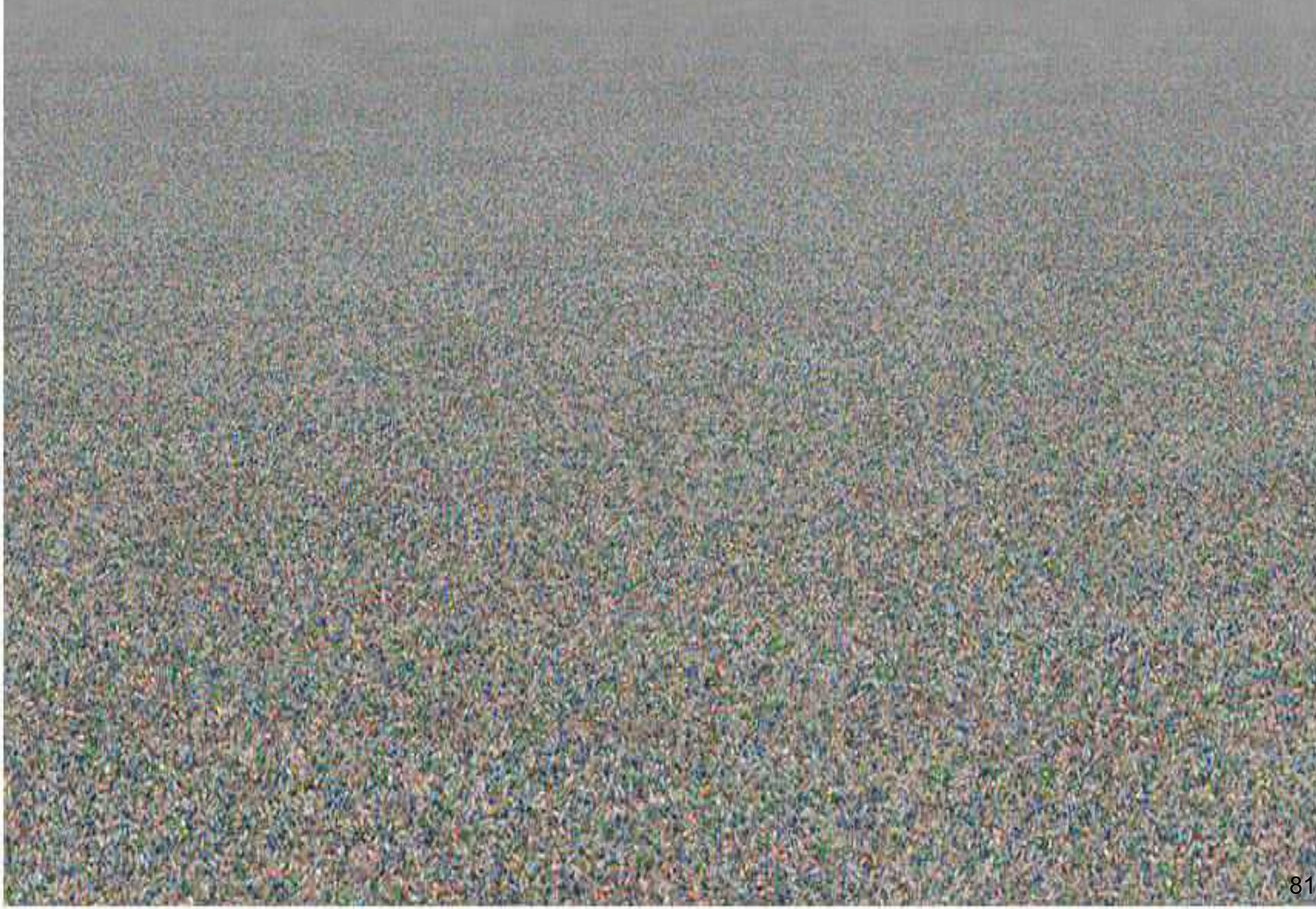
Man in essence said:

Let us consume more and more

and

we will all be happy !

Can you guess what this is?



How about now?

Certainly now, it is obvious!!

Art by Chris Jordan

Plastic Bottles, 2007
60” x120"

Depicts two million
plastic beverage bottles,
the number used in the US
every five minutes.

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Things are warming up !

Global warming is happening:

- The Arctic is melting.
- Antarctic ice shelves are breaking off.
- The weather is becoming unpredictable.
- The frequency of natural disasters and the number of people affected are increasing.
- Sea level rise is threatening the existence of small islands.

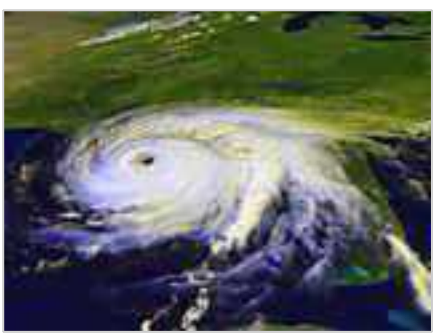
India: The Himalayan glaciers are receding !

Climate Change Worsens Natural Disasters

Avalanches, Snowstorms, Landslides

Wildfires

Floods, Droughts, Famines



Storms

Lightning

Tornadoes

Note: The above disasters can get worse due to climate change

Increased Damage from Natural Disasters

Due to:

- Uncontrolled urbanization
- High population density
- Poor planning and preparedness

Tsunamis

Volcanoes

Earthquakes

Note: The above disasters are *<u>not related</u>* to climate change

We are past the tipping point
in many aspects of the environment !

It may all come together as a catastrophe
by 2030-35.

Of course, as we saw before, it is not environment alone

Interconnected things:

- Increasing population, food prices
- Increasing disparities:
  - Marginalisation of the poor
  - Farmers in distress
- Increasing militarisation, terrorism
- Large scale corruption, frauds
- Financial crisis, economic ups and downs.

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Is Unsustainability Really a Crisis?

Different Perceptions

- Environmental problems are not as bad as they are made out to be.
- There are problems, but S&T will find solutions.
- There is a real crisis, the wolf is at the door, there is no way out !
- Hunger and poverty are more important issues, we need economic growth.
- It is all part of a Grand Design. God made this world, and He will take care of it.
- The Earth is a self-evolving and self-regulating living system and it will survive (Gaia Theory).

Human beings and
the natural world
are on a collision course.

- [World Scientists' Warning to Humanity]

So, it is much worse than I imagined !

Changes are coming !

Within your lifetime, you will see
major environmental and social changes.
They will not be pleasant
for you, your children, and humanity.

You can, however, mitigate the impact
by taking action NOW.

There is no time to lose !

Wait a minute,

Were we not living happily

for thousands of years?

Why is there a crisis now?

Earth, Nature, Man: The Long View

We have survived for so long:

- Earth: 5 billion years
- Man: 3 to 5 million years
- Civilization: 10,000 years

We know:

- Nature absorbs disturbances !
- Man is the master !
- S&T can solve all problems !
- Economic development is the key.

Why can’t we continue the same way?

Or, is something different happening now?

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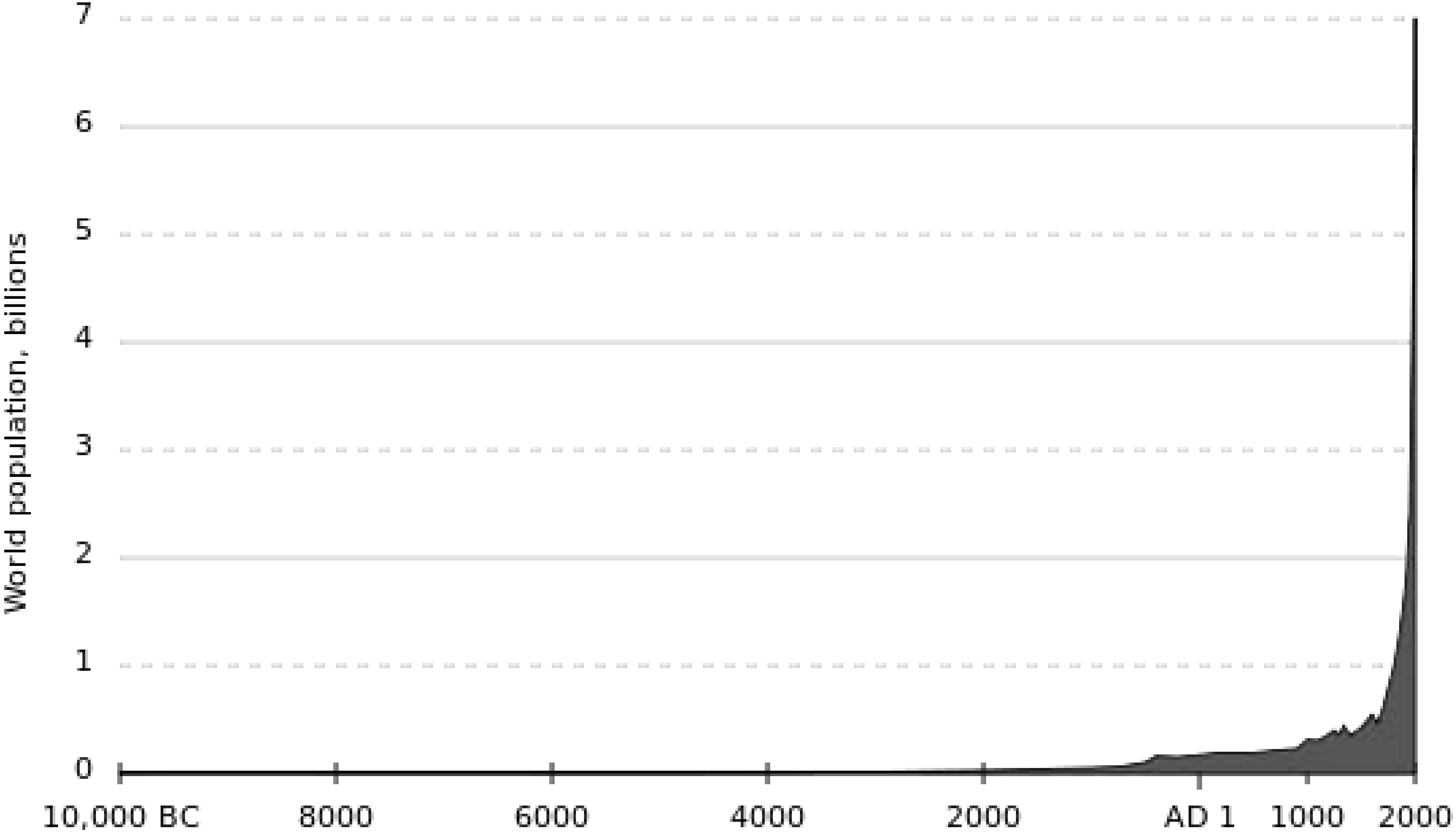
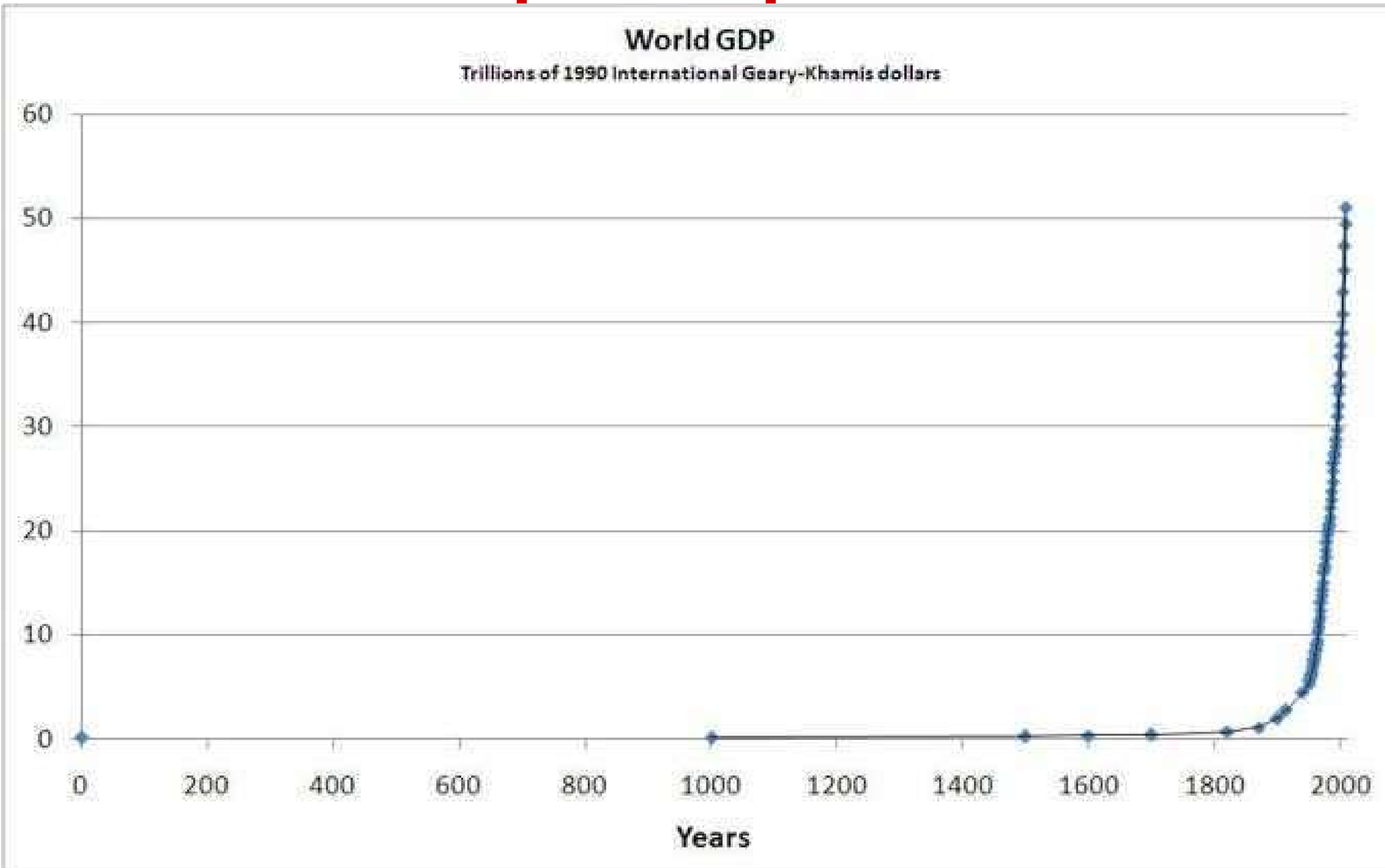
Examine the graphs on the next four slides…

The Population Spike

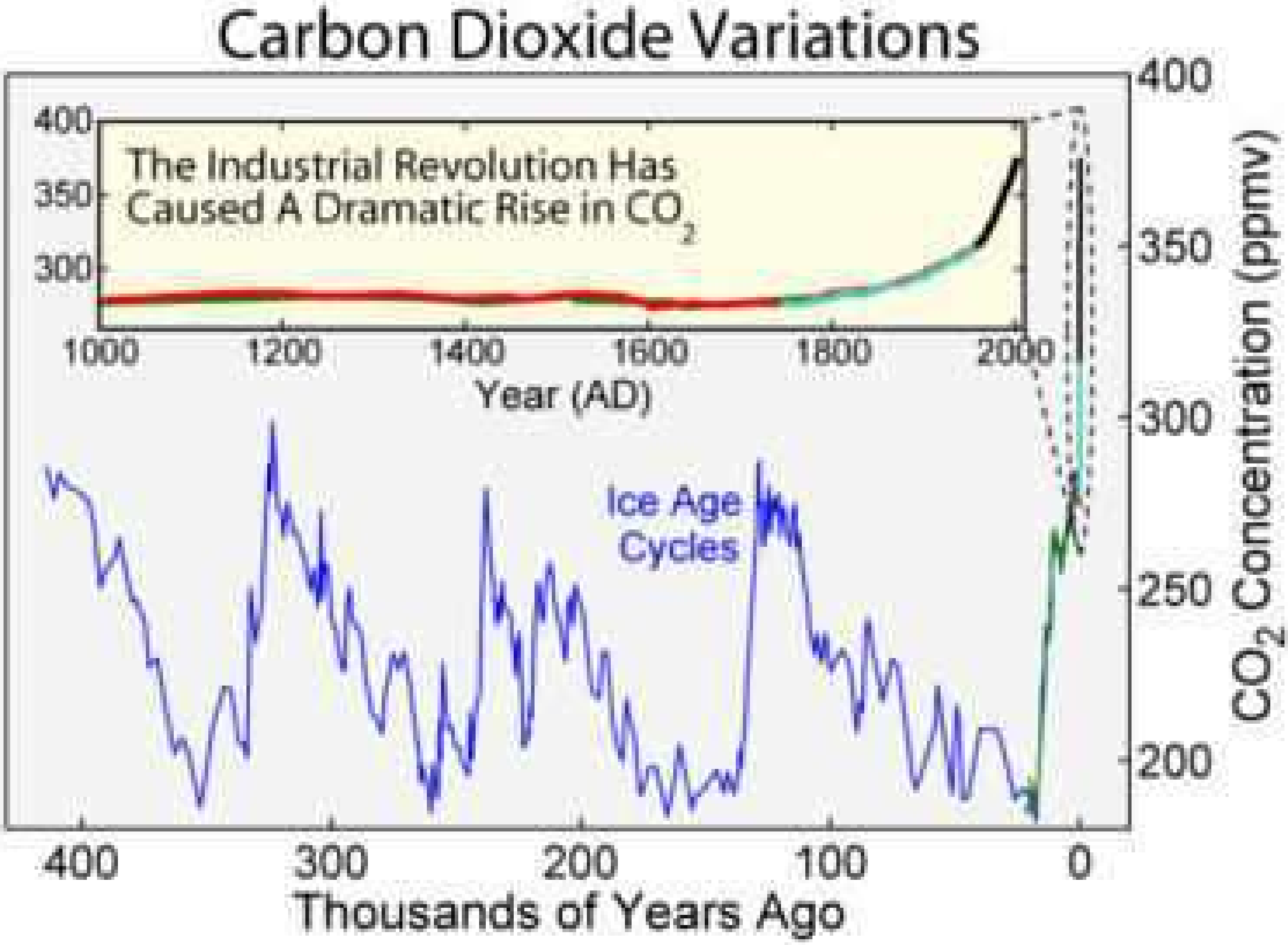


The Consumption Spike

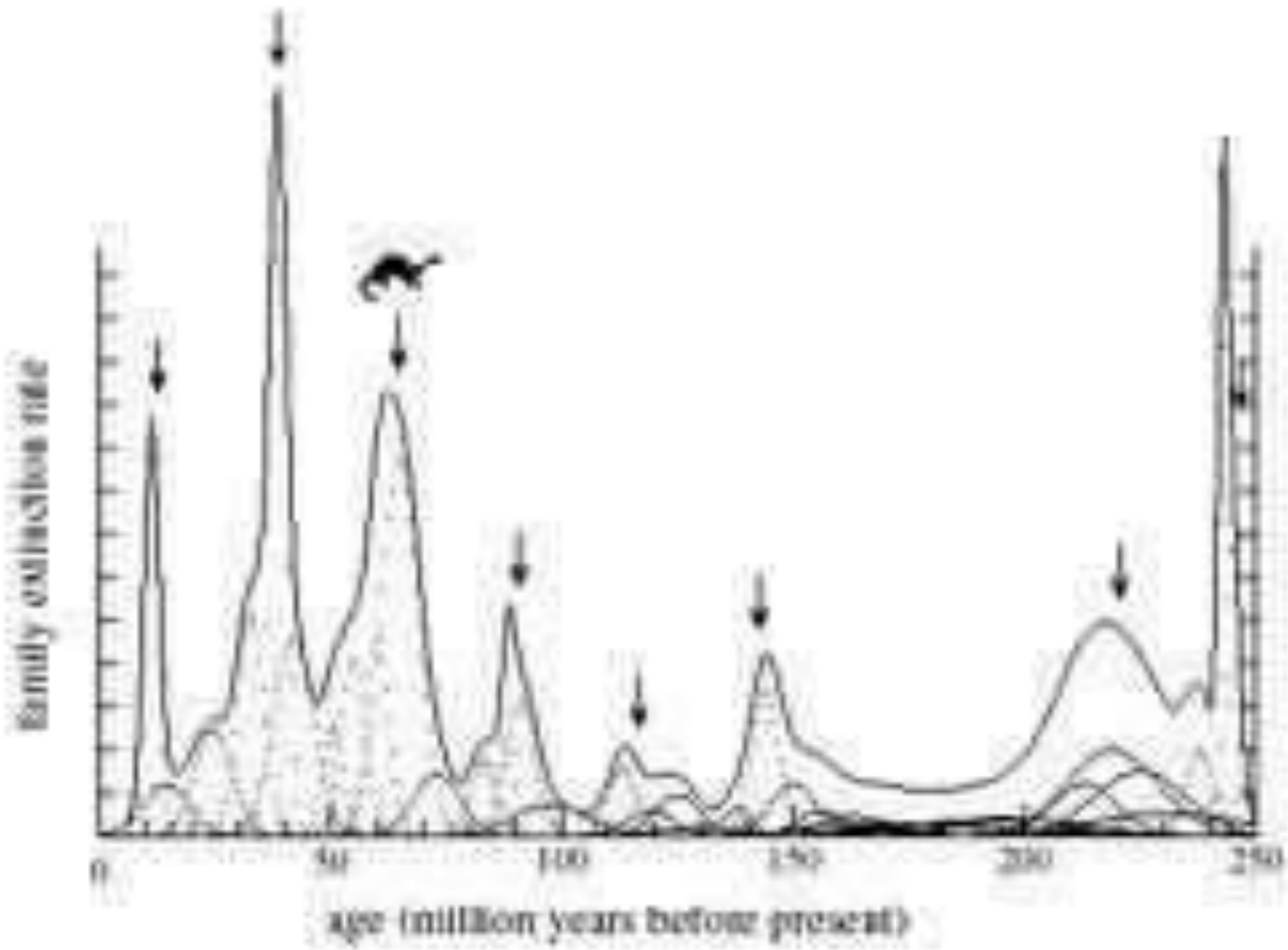


Plotted from the Data of “Historical Statistics of the World Economy: 1-2008 AD” Angus Maddison

The CO_2 Spike



The Extinction Spike



Anyone who believes that exponential growth can go on forever in a finite world is either a madman or an economist.

- Kenneth Boulding

But don’t we all want growth?
That is what our politicians, industrialists and economists are striving for.

Why do we have to question ‘economic growth’ and ‘development’ ?

We certainly don’t have to give up development. But we do have to think of development differently...very differently.

Why do the spikes occur?

GROWTH AND DEVELOPMENT

- The Idea of Progress
  - $16^{th}/17^{th}$ Century Europe
  - Industrial Revolution
- New attitude towards nature
  - Man is most important
  - Nature is for exploitation
- Exponential growth in many areas
  - Supported by Science & Technology

Let’s understand present sustainability through a model...

Unsustainability is a Tragedy of the Commons (Open Access Resources)

- The degradation of a common shared resource (commons) is inevitable in the long term when:
  - The sharing individuals are rational and self-interested (profit-minded).
  - Its use is unregulated.
- The benefits of increased consumption are immediate and privately enjoyed, while the degradation of the resource is delayed and is distributed among all.
- So, consumption goes on increasing until the resource degrades...

The socio-environmental crisis is a greatly magnified Tragedy of the Commons.

Garrett Hardin, ***1968*** *Science* **162** (3859): 1243–1248. doi:10.1126/science.162.3859.1243.PMID 5699198.

Outline

- The Nurturing Biosphere
- Well-Being and Resource Consumption
- Present Unsustainability
- Course Description
- State of the Environment
    - Forests
    - Biodiversity
    - Water
    - Ozone layer
    - Urbanization
    - Resource depletion, waste and pollution
    - Consumerism
    - Climate Change
- Perceptions of the Crisis
- Causes of the Crisis
- Environmental Movement
- Sustainable Development

What has the world done about it?

- Rachel Carson: *Silent Spring* (1962)
- Environmental movement
- Stockholm Conference (1972)
- UNEP, UN Conventions & Agreements
- Earth Summit, Agenda 21 (1992)
- World Summit on Sust. Development (2002)
- Intergovernmental Panel on Climate Change, Kyoto Protocol

What has India done about it?

- Initial legislation: Water Act, etc.
- Post-Bhopal: Many laws
- Environment Protection Act, 1986
- MoEF, Pollution Control Boards
- Environmental Impact Assessment
- Rise of civil society

Yet, environmental degradation continues unabated !

Is there no hope, then?

If things are so bad and disaster is imminent, should I just give up?

No, I must find out the real enemy of the environment !

Who is responsible?

- My neighbour who throws the garbage on the street?
- Rich countries like the US that consume and pollute a lot?
- Companies that use natural resources and throw away the waste?
- Corrupt officials who let the companies pollute?
- Municipalities that do not clear the garbage?
- Overpopulation? But it only amplifies what is basically wrong.
- Politics or the ‘system’? But, in a democracy, don’t we make the system?

Who is responsible?

- Don’t say that you have nothing to do with it; you are party to it and also the sufferer.
- Don’t say you are helpless and insignificant; small steps make big impacts.

I am responsible for the damage and for bringing change.

Our Attitudes and Actions are the Cause

- My consumption
- The waste that I create and throw away
- NIMBY (Not In My BackYard) syndrome
- The corruption that I support, directly or indirectly
- The unsustainable or polluting nature of my work, my organization

So, I am now part of the problem !

Can I become a part of the solution ?

Yes!

We are the ones

we have been waiting for!

- June Jordan

I am the real cause of the problem

so I have to begin with myself !

Fine. I’m ready to do what it takes.

But what am I supposed to do?

What are WE supposed to do?

We all need to work towards:

SUSTAINABLE DEVELOPMENT

Outline

- The Nurturing Biosphere
- Well-Being and Resource Consumption
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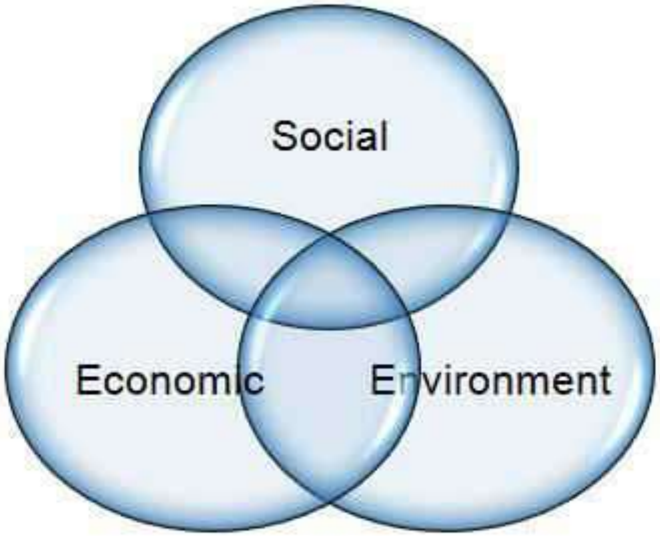
- Causes of the Crisis
- Environmental Movement
- Sustainable Development

Sustainable Development (SD)

- SD is the **economic development** to meet **human needs** while preserving the **environment.**
- Meet needs into the indefinite future.
- Present economic growth is unsustainable since it leads to social inequities and environmental damage.
- Economy, Society, Environment: 3 interdependent and mutually reinforcing pillars of SD.



In order to work towards Sustainable Development, we need to learn a lot of things….

We need to study this course for starters!

So, let's get on with it!

Thank You

Look forward to learning more about our wonderful environment with you…

UNIT 6: SOCIETY AND ENVIRONMENT

World Population

- Present Population = 7.5 billion

China (1.5 billion people) and India (1.3 billion people) are the most populous countries in the world (19& 18% of the total world population)

- Projected population→ 9.7 billion in **2050**

It is expected that India will surpass China and become the largest populated country around 2022, while Nigeria's population will be more than that of United States by 2050

Population growth in India

Economic Survey of India 2018-19

Population growth rate expected to be

- less than 1% from 2021-2031
- under 0.5% from 2031-2041

Anonymous. 2019. Greying India must delay retirement. The Hindu, Page, 11, July 5, Coimbatore Edn.

Population growth in India

Economic Survey of India 2018-19

- The reason being fall in Total Fertility Rate (TFR), which is projected to decline between 2021-2041 & fall below replacement level fertility at 1.8 as early as 2021
- Current TFR in 14 out of 22 major States of India is already below the effective Replacement Level Fertility

Anonymous. 2019. Greying India must delay retirement. The Hindu, Page, 11, July 5, Coimbatore Edn.

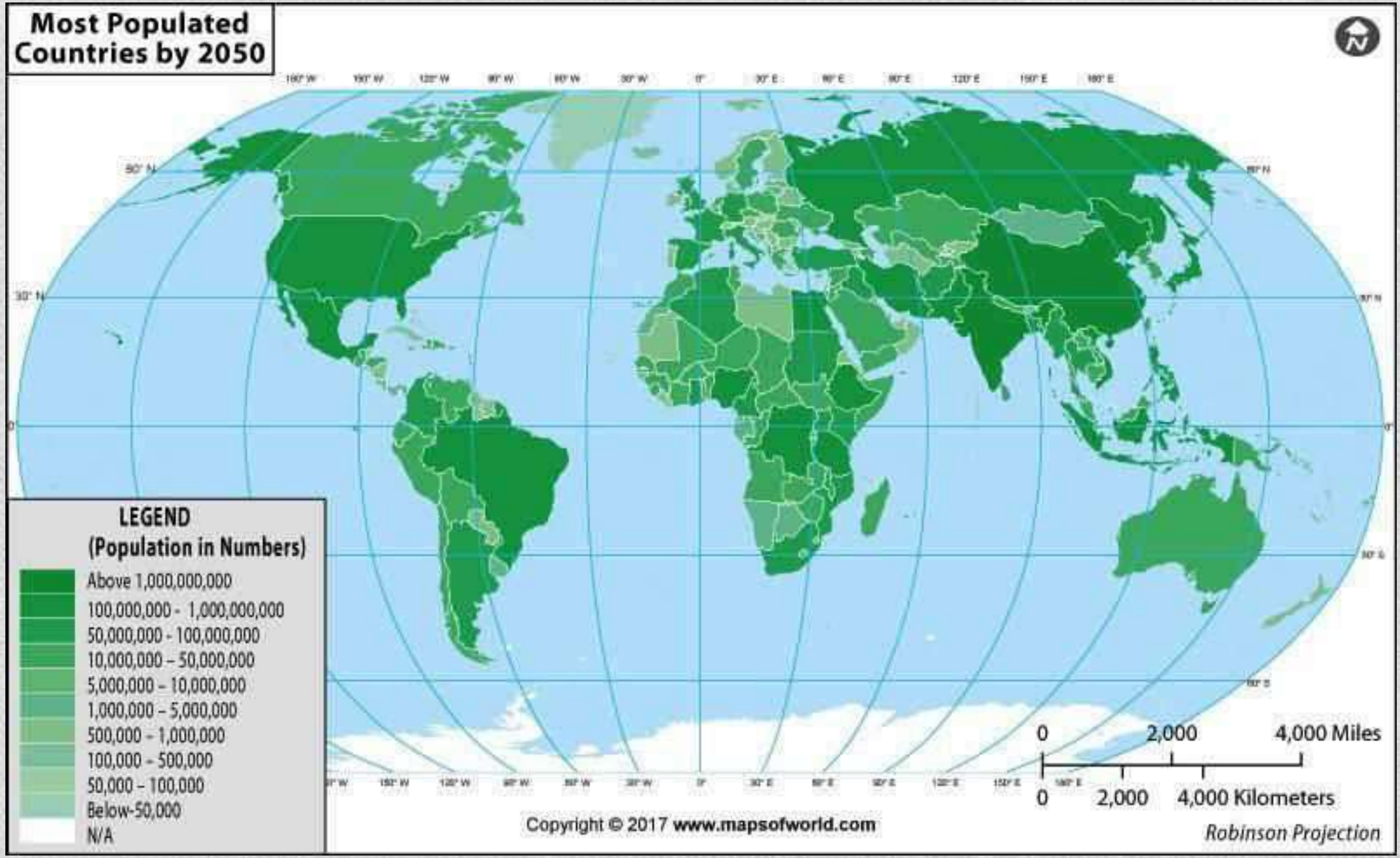
Population growth in India

<u>Economic Survey of India 2018-19</u>

- Size of elderly population >60 yrs age is expected to nearly double from 8.6% in 2011 to 16% by 2041
- Size of population 0-19 yrs age is on decline and is likely to drop from as high as 41% in 2011 to 25% by 2041

Anonymous. 2019. Greying India must delay retirement. The Hindu, Page, 11, July 5, Coimbatore Edn.

Population projection



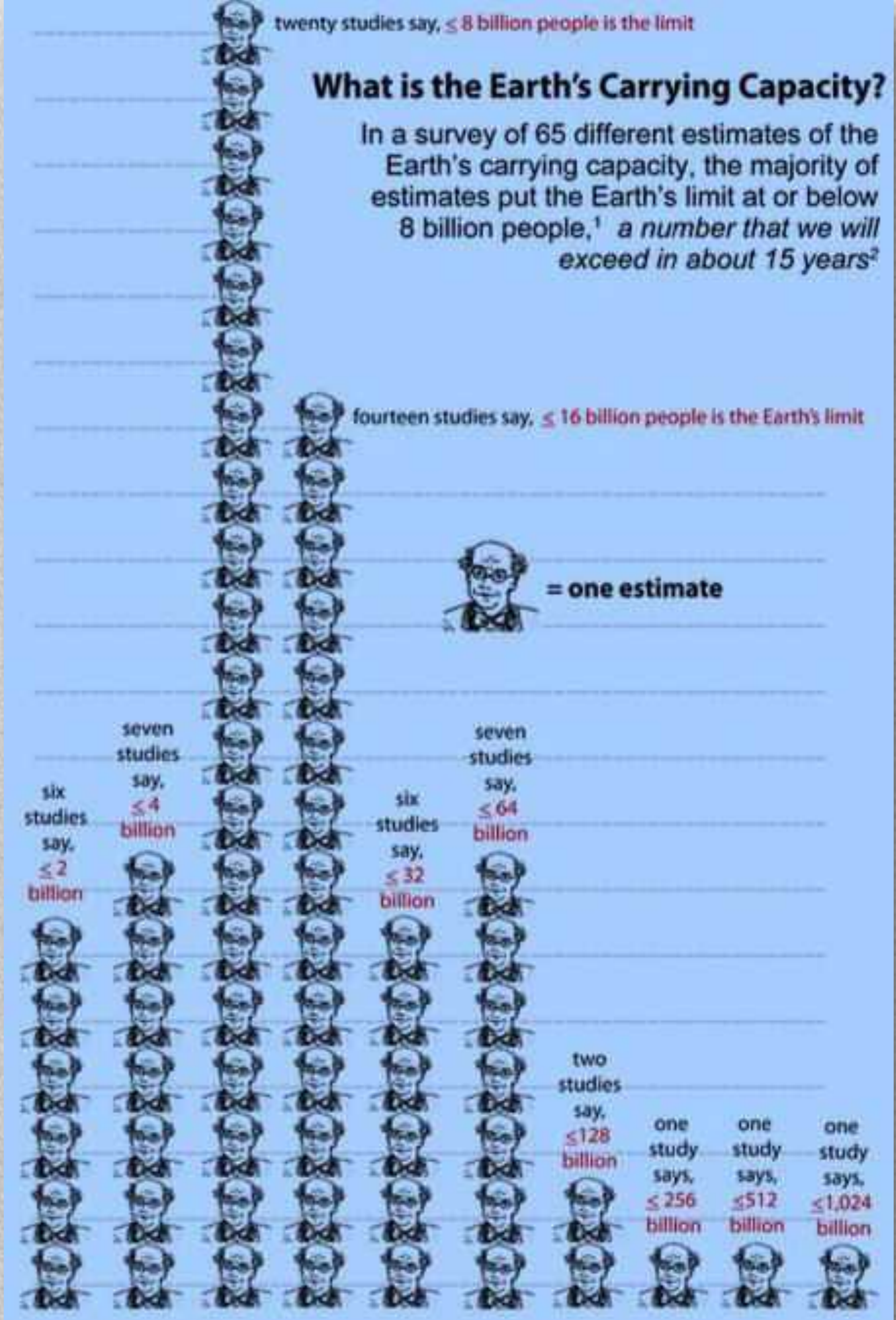
By [2050](), six countries are expected to exceed 300 million: China, India, Indonesia, Nigeria, Pakistan, and the USA.

An elephant in the room!!

Overpopulation- Where the number of human population exceeds the earth's [carrying capacity](#).

Carrying capacity is the maximum size of population that the earth can support indefinitely in terms of space and availability of other natural resources.

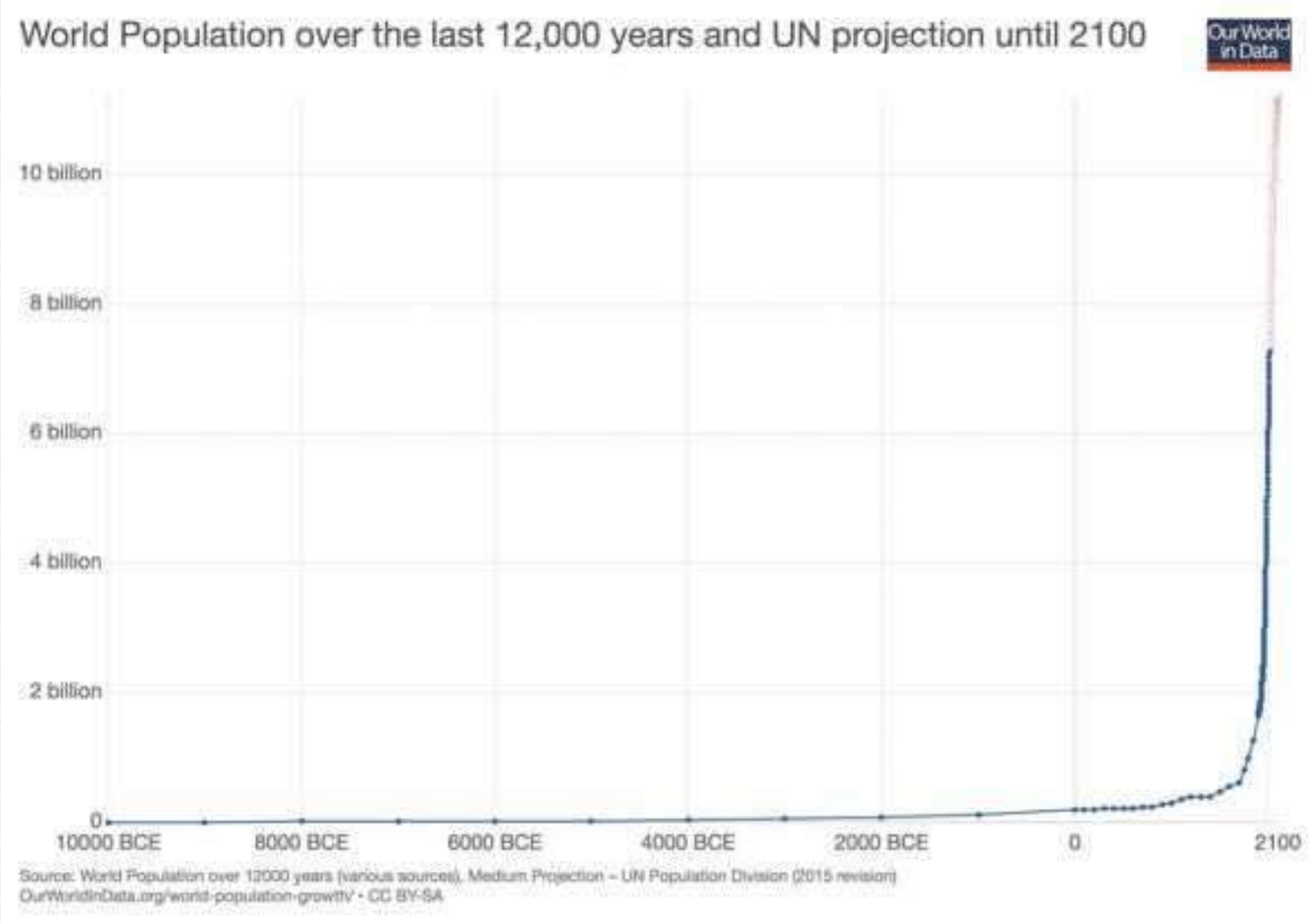
We already consume five times more than that the planet can supply; most of the studies showcasing earth's carrying capacity is **8 billion people, almost equal to the current 7.5 billion!!!**



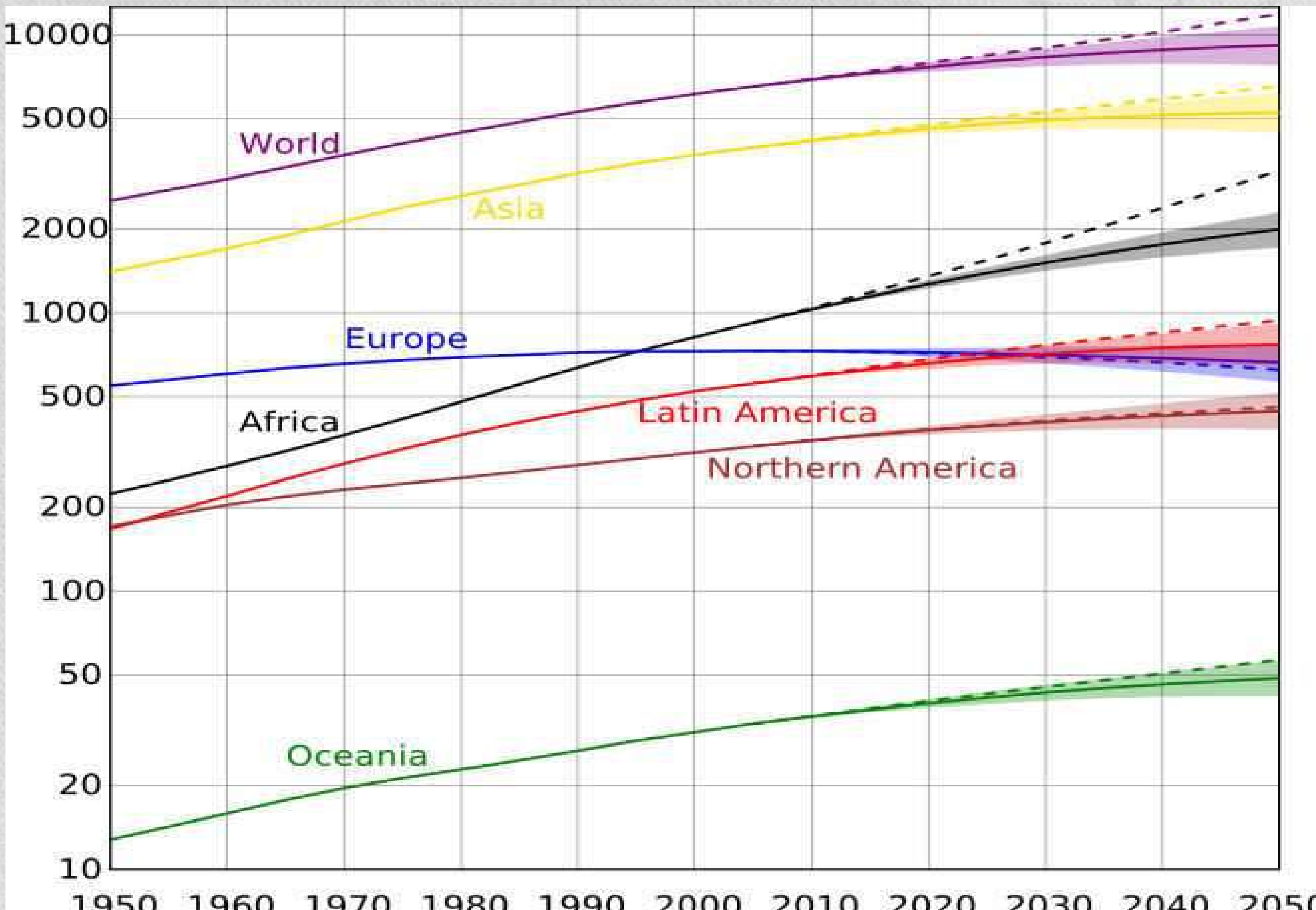
Picture courtesy: Cohen, J. E. (2003). Human population: the next half century. [Research Support, U.S. Gov't, Non-P.H.S.]. Science, 302(5648), 1172-1175. doi: 10.1126/science.1088665

"The world has enough for everyone's need, but not enough for everyone's greed." M.K. Gandhi

World Population growth



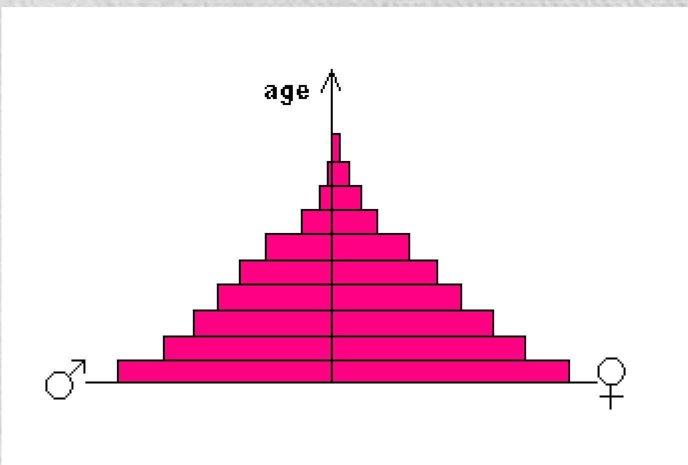
World Population 20-21st Centuries (in mi.)



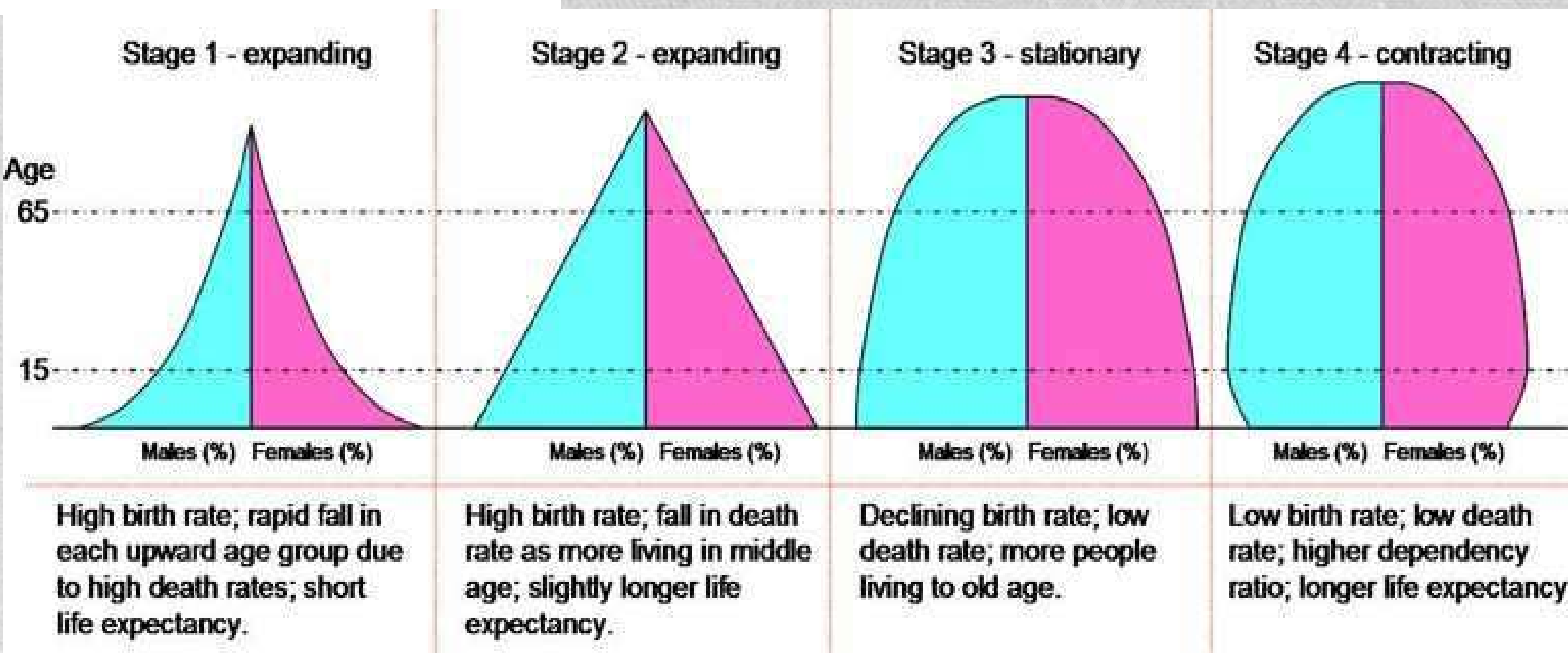
Population: Terminologies and definitions

- Birth Rate = no. of live births/1000
- Death Rate = no. of deaths/1000
- Natural Increase (%) = 100 x (birth rate - death rate)/total Population
- Net migration (%) = 100 x (immigration - emigration)/total Population
- Growth Rate (%) = natural increase + net migration
- Doubling Time: Yrs. for population to double at current growth rate
- The total fertility rate (TFR) = avg. no. of children a woman would have over her lifetime.
- Age Dependency Ratio = (No. of people under 15 and older than 64)/(No. of people bet. 15-64)
- Life expectancy = the average age a person in the population is expected to reach.

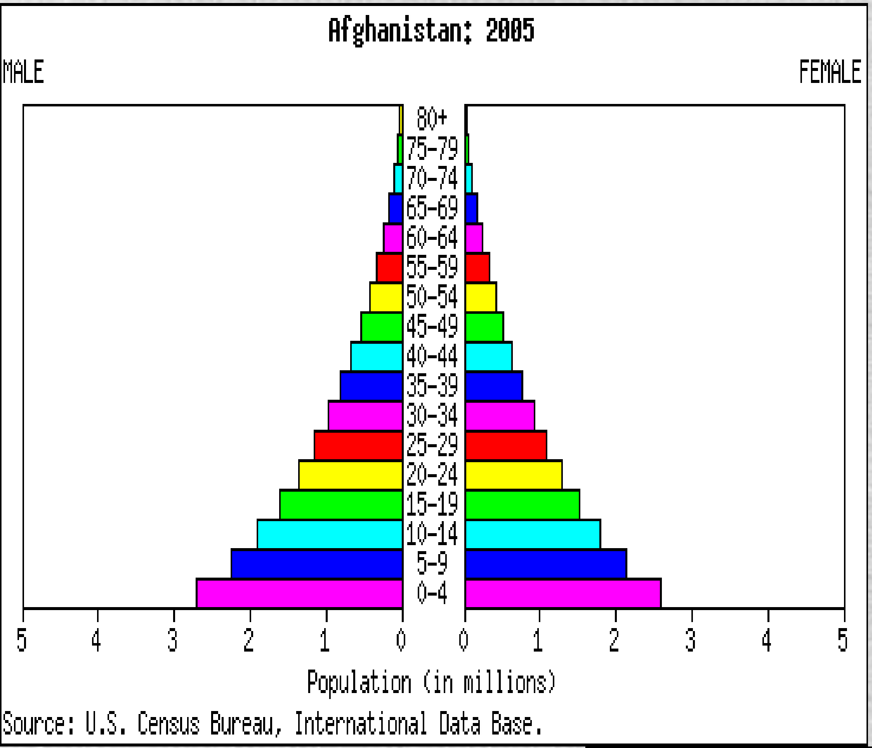
Population Pyramids



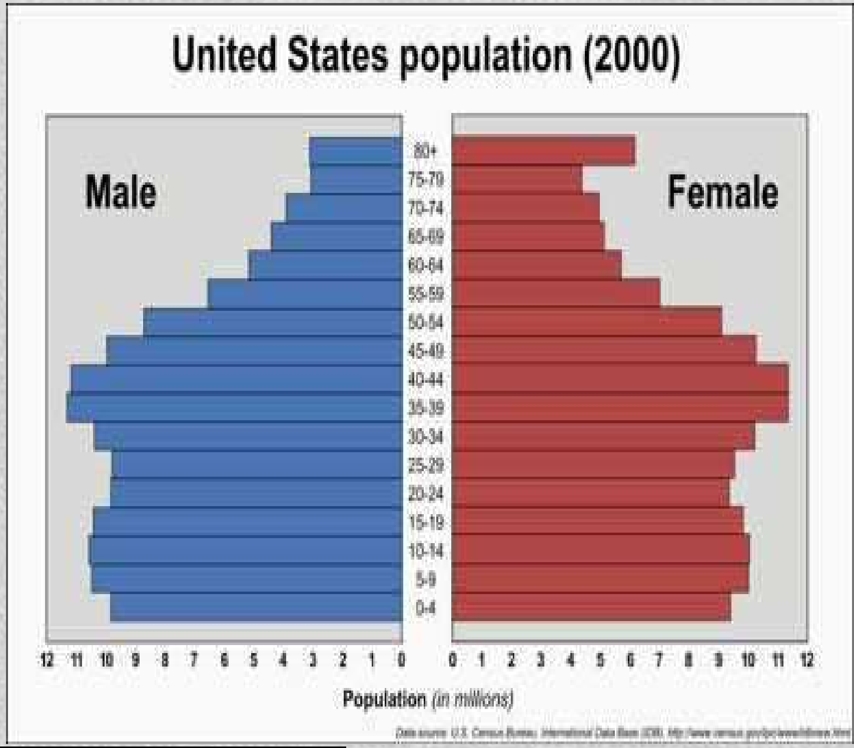
Age-Sex Pyramid or Age Structure Diagram



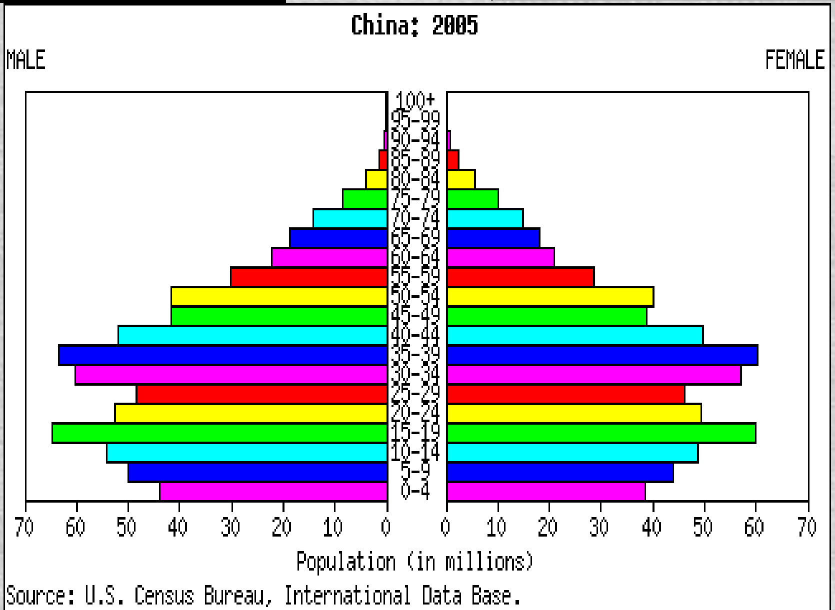
Example: **Expanding—Youth Bulge**



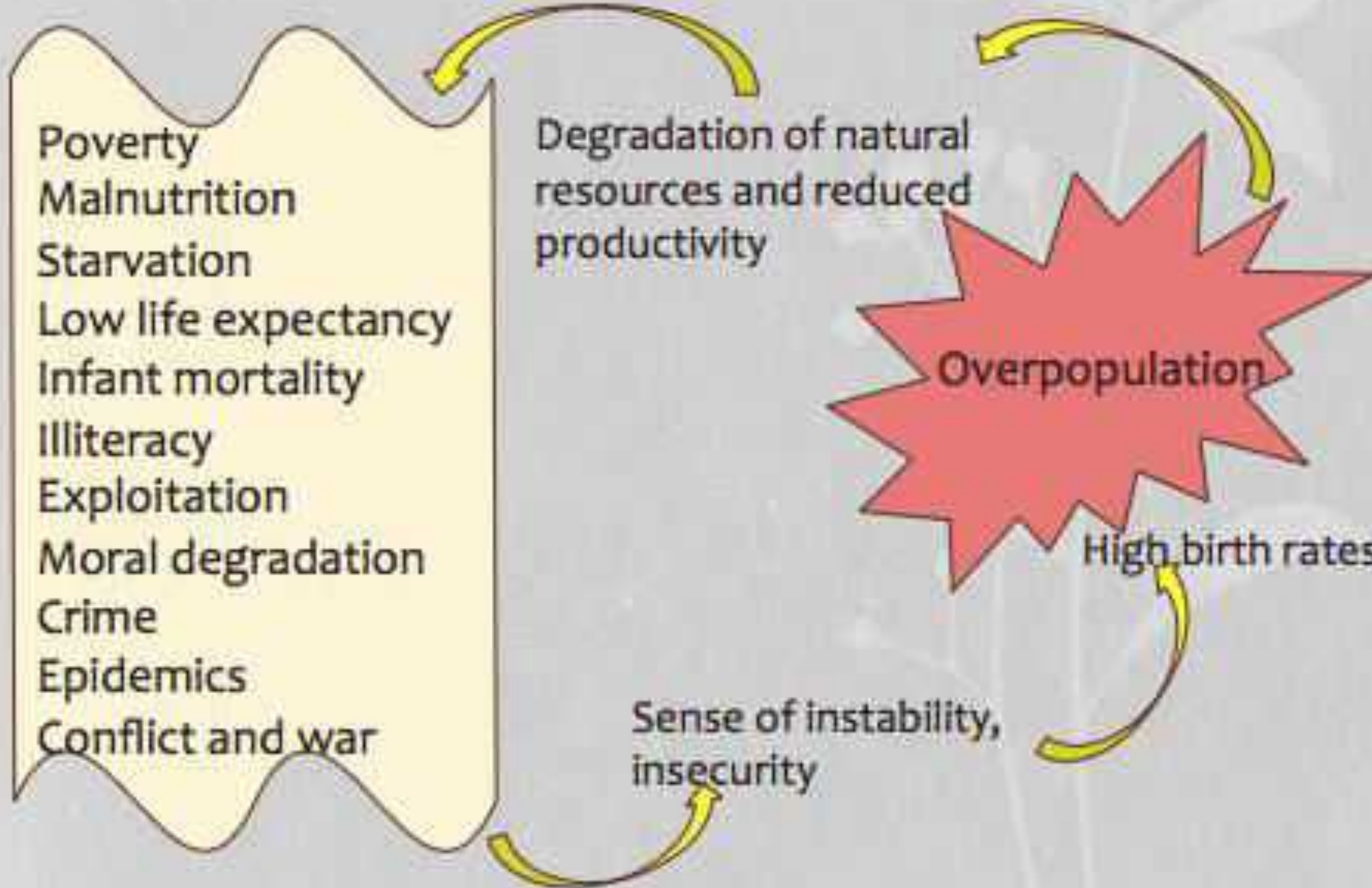
Example: **Stationary—slight bulge & slimming**



Example: **Contracting—after massive bulge**



Overpopulation: The Vicious Cycle



Why is population growth high in underdeveloped countries/regions?

Insecurity due to poverty and socio-political instability (conflict, war, poor law & order):

More children provides a greater sense of security--"more hands to work" and a "retirement plan" especially among agricultural or low wage workers.

Male-dominated uneducated and orthodox society

Girls are looked upon as a liability. Also causes a skewed sex-ratio & child marriage.

Low women literacy, unempowered women

Low knowledge, availability and social acceptance of family planning

Stable families based on traditional values esp. in rural areas (having adequate resources) :

Traditionally, children are looked upon as a sign of prosperity: "gifts of God"; hence, they are not to be limited.

On the contrary, in modern societies and urban areas bringing up of children is viewed as an additional burden, expense or an impediment to women's careers. Also, high rates of divorce and separation in modern urban societies tend to limit the number of children. But modern urban societies have their own problems.

So society must maintain the stability and good values of traditional family systems, while adopting modern thinking to remove their deficiencies.

Why is population growth high in underdeveloped countries/regions?

Religious reasons

Family planning is considered to be taboo by some religions.

Producing more children is considered virtuous; and the expansion of the faith

A reinterpretation of traditional and religious values in the modern context is necessary.

How to Stop the Population Explosion?

A comprehensive solution is needed. It includes:

- Providing good governance
  - Political, economic and social stability
  - Fair people-centric policies (incl. economic policies)
  - Efficient law and order system
- Economic measures
  - Reduce poverty and economic stratification
  - Provide reasonable and adequate local means of livelihood

How to Stop the Population Explosion?

- Providing regular environmentally conscious, value-based education
- Empowerment of women in society through awareness measures, women's support groups, employment and financial independence of women,
- Improve universal affordability and social acceptance of family planning methods
- Re-interpretation of social values:
  - The belief that a male-child alone can support parents in their old age and carry forward the family name can be replaced by the idea that male or female issues can support parents and bring good name to their family through their upright character and high achievements.
  - Prosperity does not mean having ***more*** children; it means ***<u>better</u>*** children. i.e. Families should focus on better education, upbringing and values in one or two children.
- Remove resource-constraints, and overcome natural disasters, etc. to reduce social insecurity, infant mortality and birth-rates

A well-informed population can essentially be the change makers of a society!

They play quintessential roles in a democratic system and help building sustainable societies

People’s movements to save nature

Chipko movement (Chipko Andolan)

Bishnoi community of Rajasthan started Chipko movement around 260 years back in the early part of the 18th century

People from 84 villages led by a woman **Amrita Devi** laid down their lives in protecting the trees from being felled on the orders of the King of Jodhpur.

Picture courtesy: Wikipedia

In 1973- Indigenous people of the village of Mandal in the upper Alakananda valley protested and saved the forest trees against government's decision to cut them for a sports-good company

Non violent (inspired from Gandhiji’s) movement by hug or stick to (‘chipko’) trees

Prime figures: Sunder Lal Bahuguna (Environmentalist), Gaura Devi (elderly woman from indigenous community), Mr. Chandi Prasad Bhatt of Dasoli Gram Swarajya Sangh(DGSS)

'What do the forests bear? Soil, water and pure air' **the Chipko slogan**

"The forest nurtures us like a mother; you will only be able to use your axes on it but you have to use them first on us" Gaura Devi

Chipko is considered as the beginning point in the history of nature conservation in India

Its success triggered similar conservation movements elsewhere in the country

Courtesy: Harmony magazine

Silent valley movement

People's movement that saved a pristine moist evergreen forest in Kerala's Palakkad District from being destroyed by a hydroelectric project proposed by the state government in the Kunthi river, a tributary of the Bharathapuzha River

The Kerala State Electricity Board, KSEB proposed the hydroelectric project across the Kunthi river in the pristine forest area to generate electricity for the state of Kerala with the installation of four units of 60 MW each, to Irrigate an additional 100 sq km and boost the economy of the state.

The major impacts of the projects include

Submergence of 8.3 sq km of untouched moist evergreen forest with several species of flora and fauna including endemic species

The Movement...

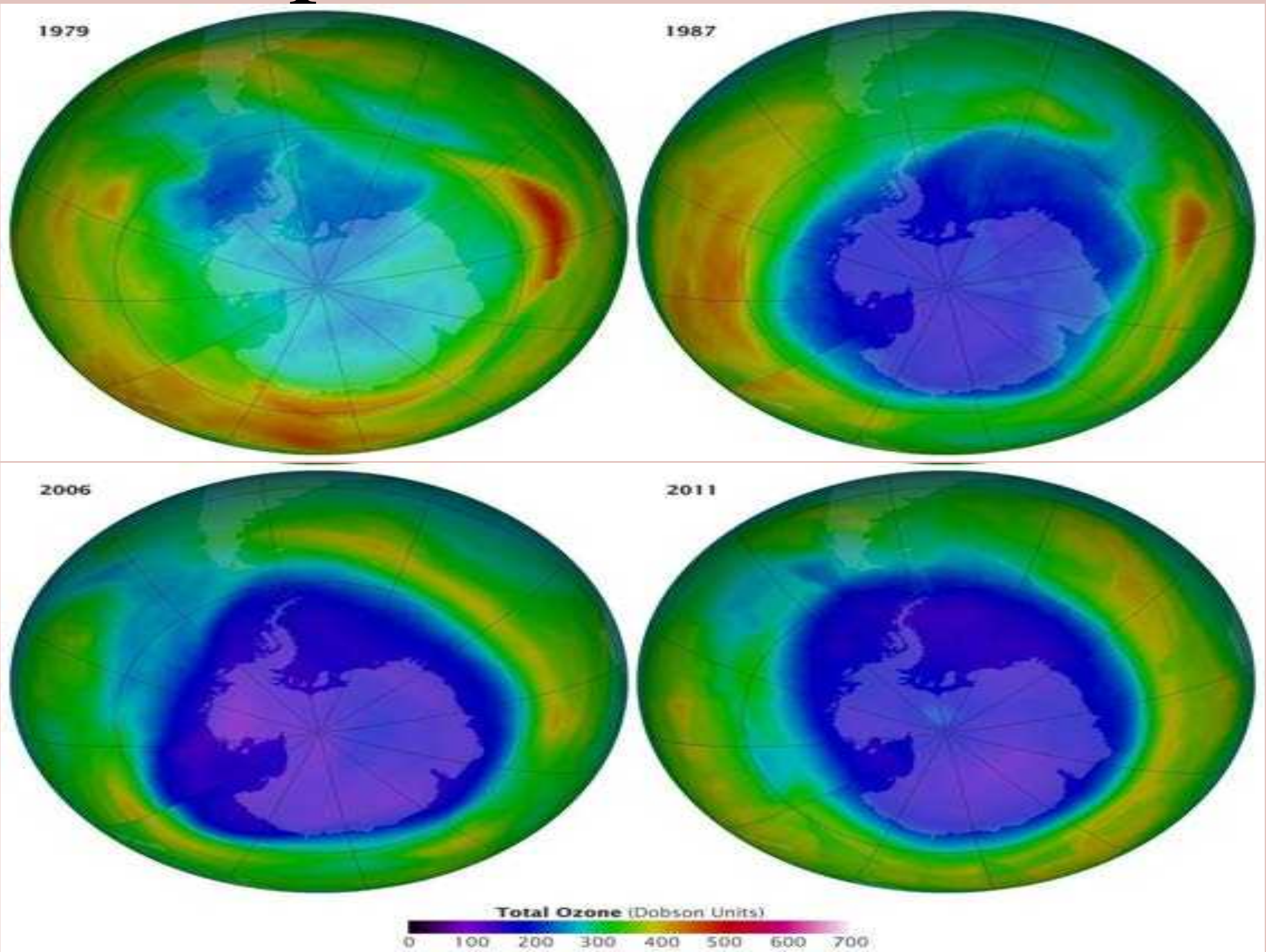
Citizens from almost all walks of life participated-scientists, researchers, activists, literary figures, journalists, teachers, students and common people

Non violent movements include in the protests include writing letters to the editors of newspapers, organizing seminars, widespread awareness programmes by school going students and local clubs, and drafting petitions and appeals in court and other high offices

Some of the notable personalities involved: Salim Ali, Madhav Gadgil, MS Swaminathan, Sathish Chandran Nair, V.S. Vijayan, MV Krishna Warrier and Sugatha Kumari Kerala Sasthra Sahithya Parishad (people's science movement) played a vital role in the movement

In 1983 the then Prime Minister of India, Indira Gandhi, decided to abandon the Project and the Silent Valley forests were declared as a National Park.

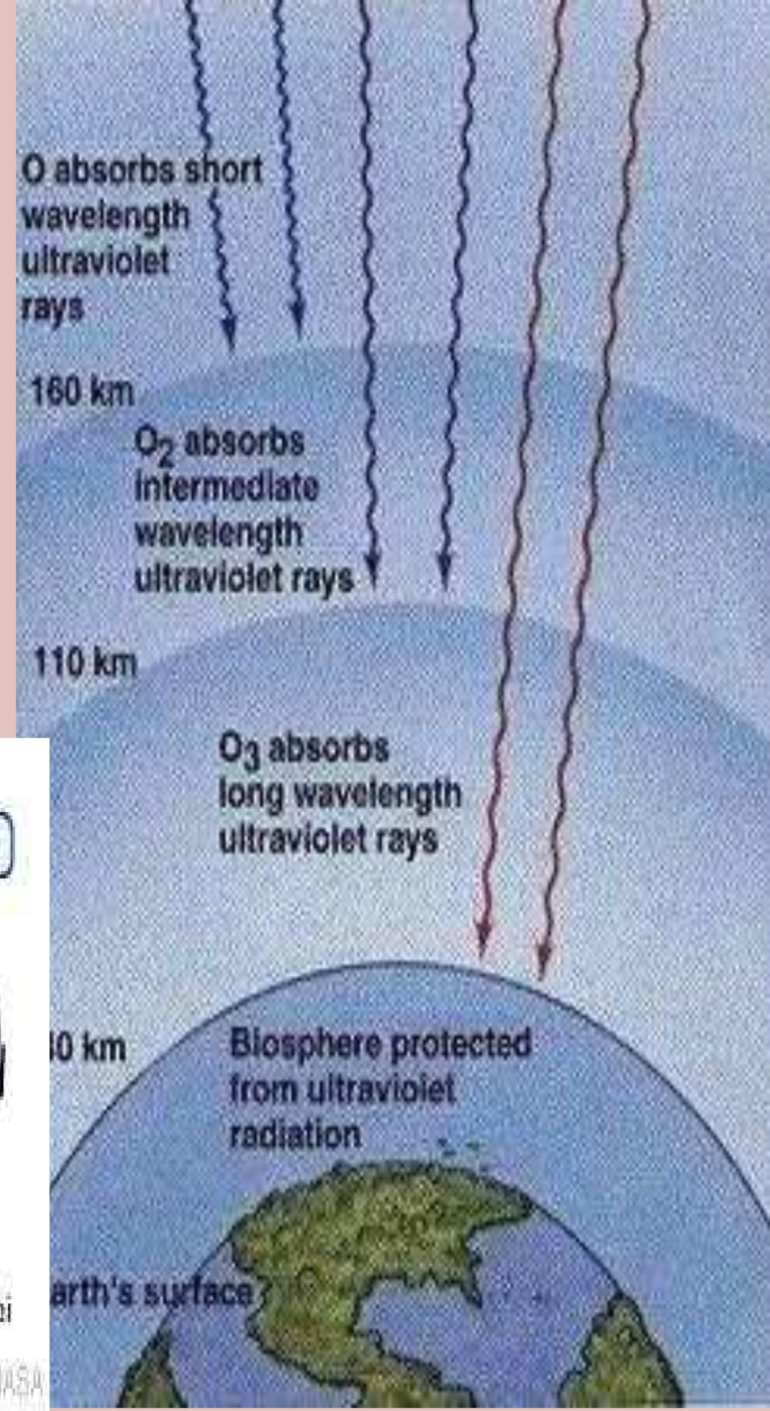
Ozone Depletion

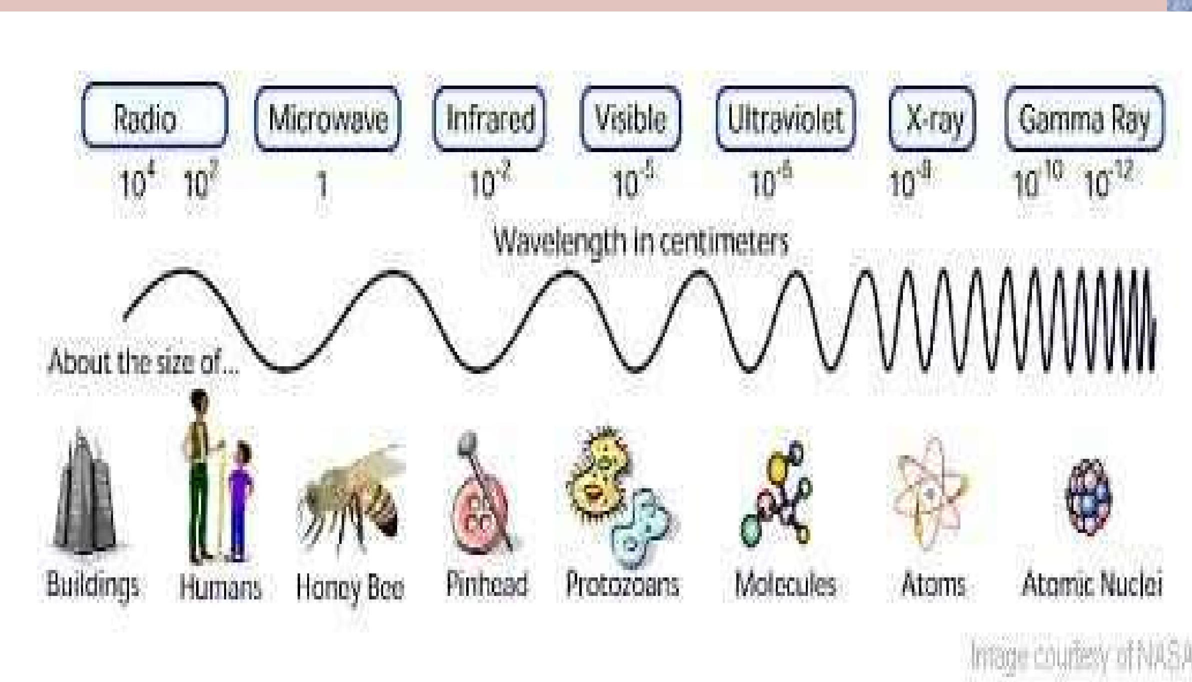


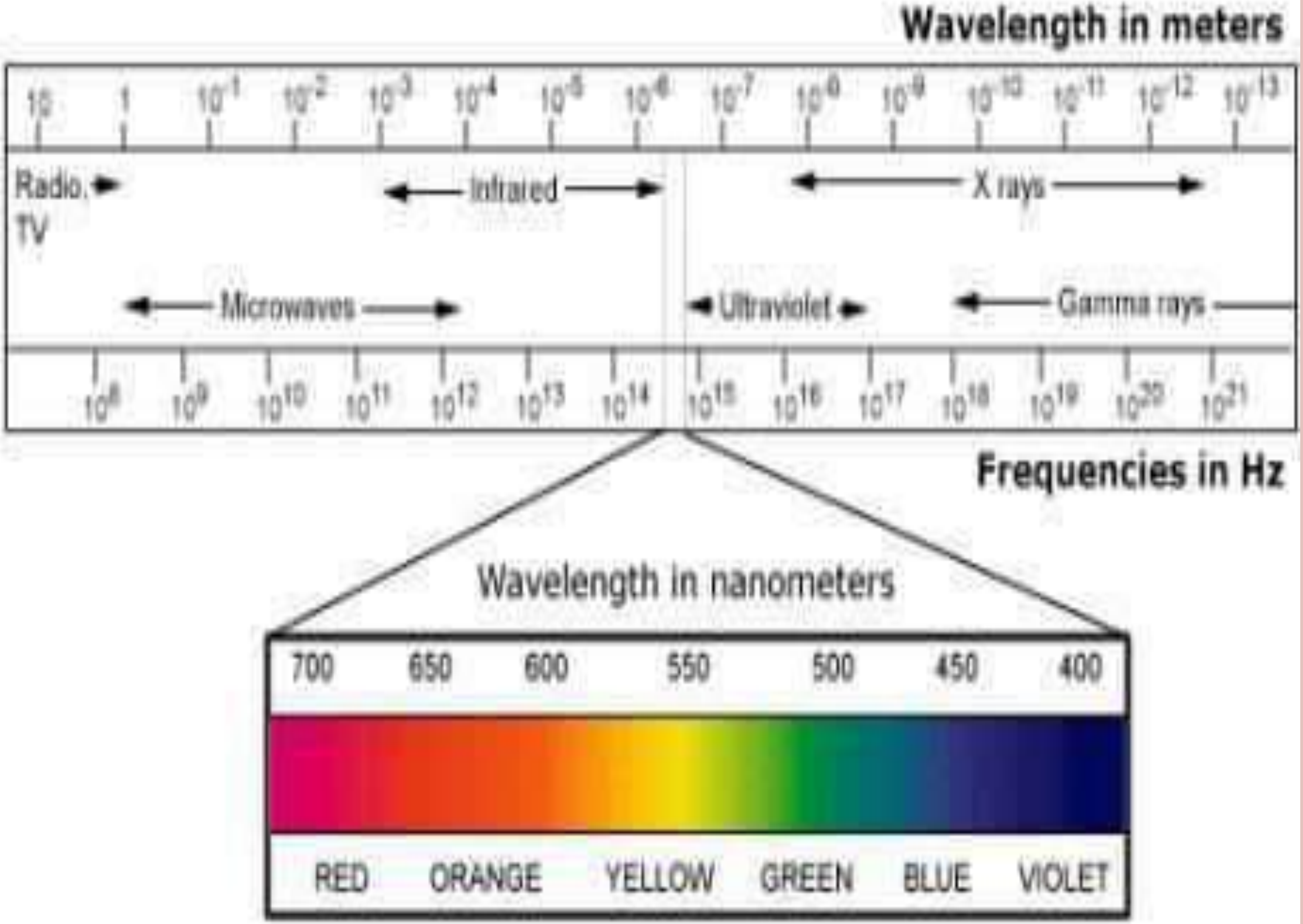
Images by NASA on the status of the Antarctic Ozone Hole on September 16 of the years 1979,1987,2006& 2011

Ozone

- About 90% of Ozone resides in the stratosphere
- It protects us from UV radiations
- Increase in the Troposphere ozone can contribute to raising global temperature
- Ozone is continuously created in the stratosphere by absorption of UV radiation, while it is continuously being removed by various chemical reactions that convert it back to molecular oxygen


O absorbs short wavelength ultraviolet rays
160 km
O_2 absorbs intermediate wavelength ultraviolet rays
110 km
O_3 absorbs long wavelength ultraviolet rays
Biosphere protected from ultraviolet radiation


Radio
Microwave
Infrared
Visible
Ultraviolet
X-ray
Gamma Ray
Wavelength in centimeters
About the size of...
Buildings
Humans
Honey Bee
Pinhead
Protozoans
Molecules
Atoms
Atomic Nuclei
Image courtesy of NASA



Wavelength in meters
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
Radio, TV
Infrared
X rays
Microwaves
Ultraviolet
Gamma rays
10^{8}
10^{9}
10^{10}
10^{11}
10^{12}
10^{13}
10^{14}
10^{15}
10^{16}
10^{17}
10^{18}
10^{19}
10^{20}
10^{21}
Frequencies in Hz
Wavelength in nanometers
700
650
600
550
500
450
400
RED
ORANGE
YELLOW
GREEN
BLUE
VIOLET

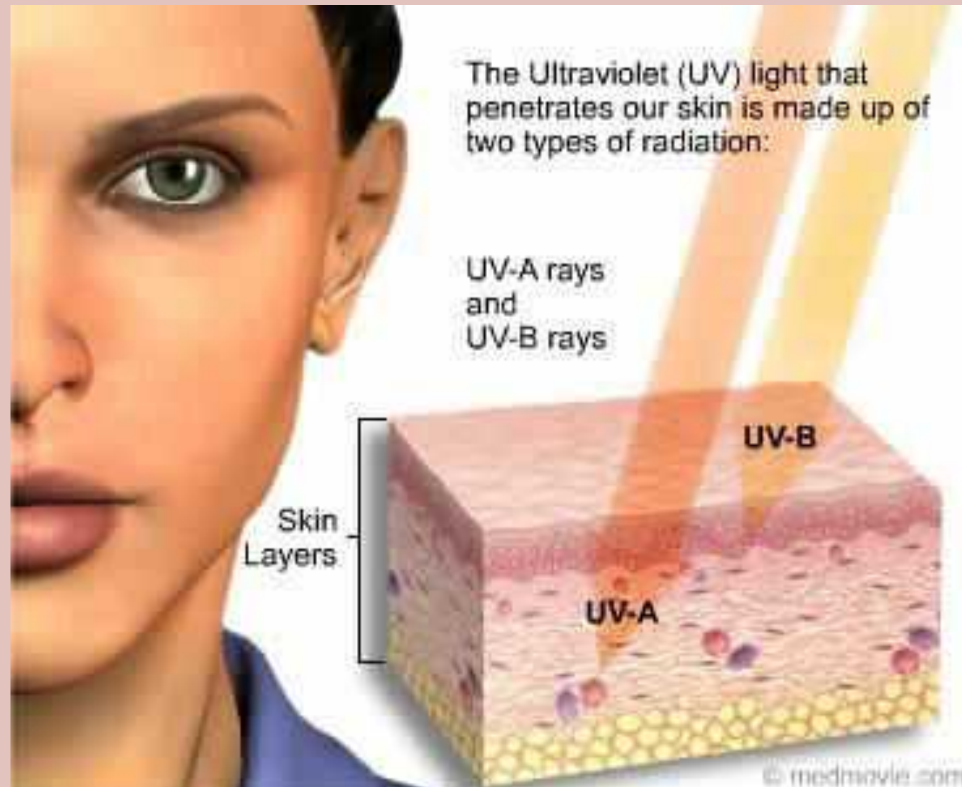
Classification of UV Rays

Name	Abbr.	λ range in nm	Energy/ photon (eV)
UV A, long wave, or black light	UVA	400 –315	3.10–3.94
Near	NUV	400 –300	3.10–4.13
UV B or medium wave	UVB	315 –280	3.94–4.43
Middle	MUV	300 –200	4.13–6.20
UV C, short wave, or germicidal	UVC	280 –100	4.43–12.4
Far	FUV	200 –122	6.20–10.2
Vacuum	VUV	200 –100	6.20–12.4
Low	LUV	100 –88	12.4–14.1
Super	SUV	150 –10	8.28–124
Extreme	EUV	121 –10	10.2–124

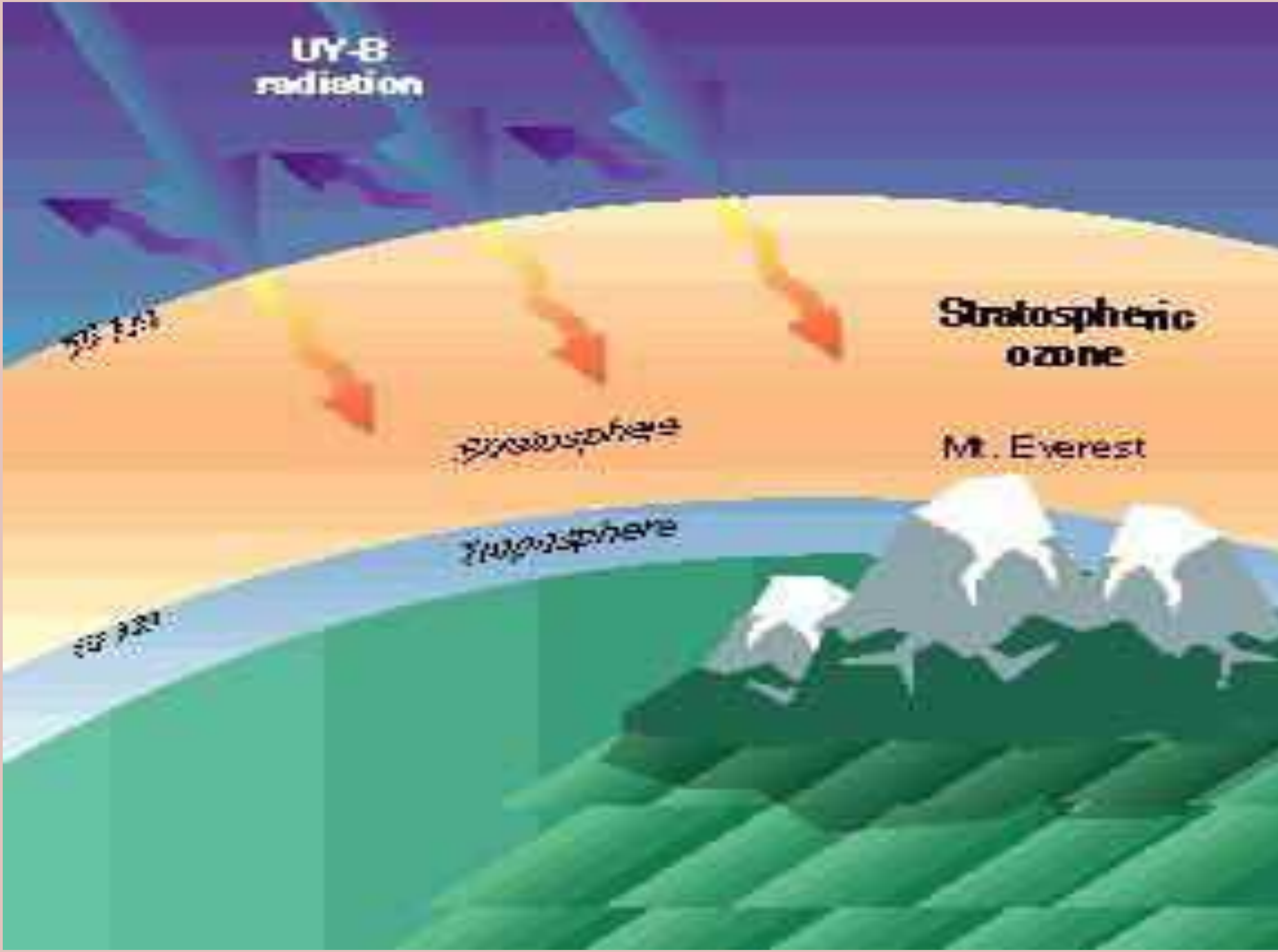
UV Skin Penetration

- UVC and much of UVB rays are absorbed by the Earth's ozone layer.
- UVA and some UVB rays are transmitted through the atmosphere,
- UVB rays (short wavelength) reach only the outer layer of your skin (the epidermis)
- UVA rays (longer wavelength) and can penetrate the middle layer of your skin (the dermis).
- Both Cause sunburns.

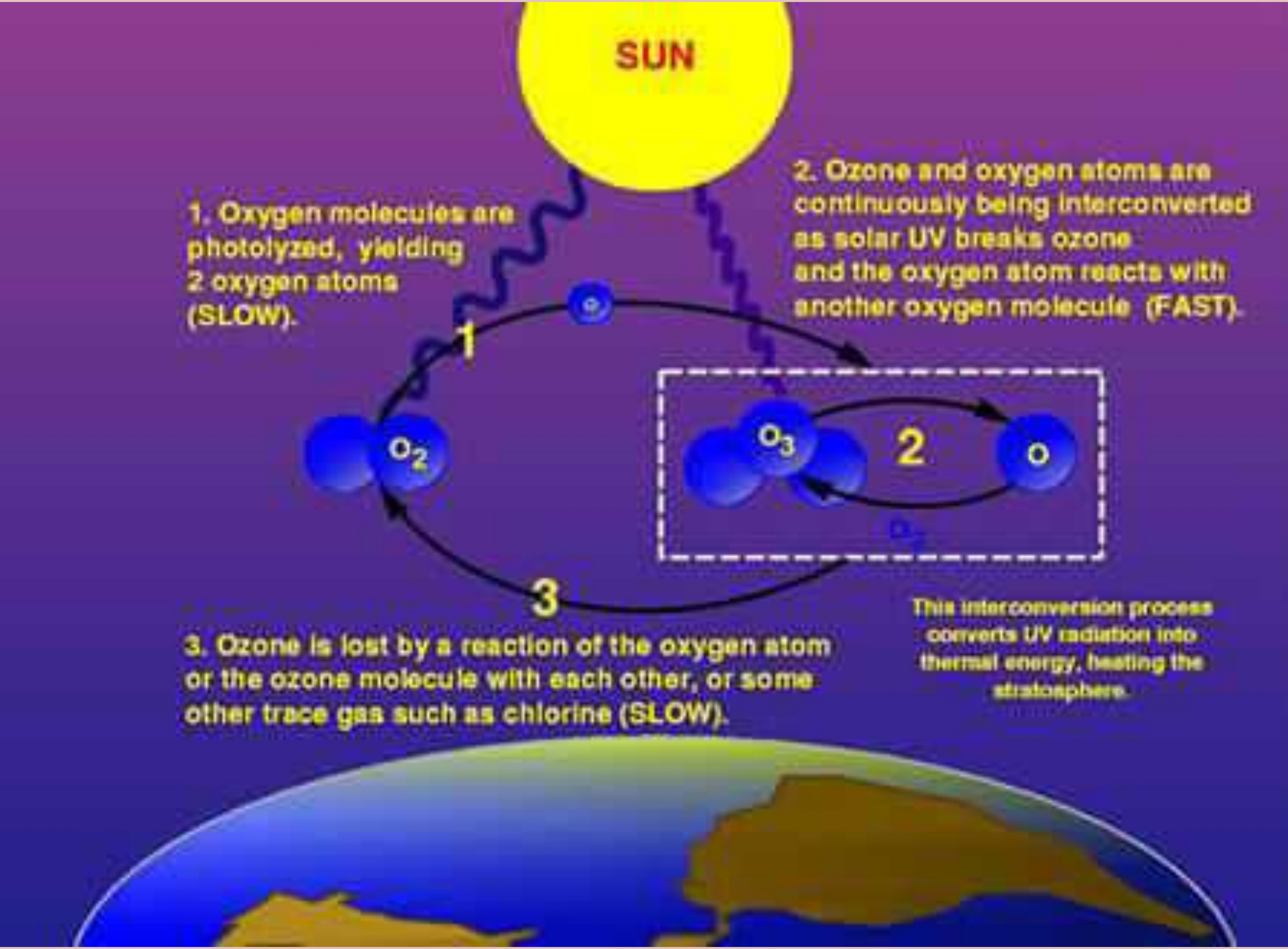
Sunburn—Skin damage due to UV



- UVB radiation (280 - 320) has been linked to skin cancer, cataracts, damage to materials like plastics, and harm to certain crops and marine organisms. Although some UVB reaches the surface without ozone depletion, its harmful effects will increase as a result of this problem



UV-B
radiation
Stratospheric
ozone
Stratosphere
Mt. Everest
Troposphere


SUN
1. Oxygen molecules are photolyzed, yielding 2 oxygen atoms (SLOW).
2. Ozone and oxygen atoms are continuously being interconverted as solar UV breaks ozone and the oxygen atom reacts with another oxygen molecule (FAST).
1
O
O2
O3
2
3
3. Ozone is lost by a reaction of the oxygen atom or the ozone molecule with each other, or some other trace gas such as chlorine (SLOW).
This interconversion process converts UV radiation into thermal energy, heating the stratosphere.

Natural Formation and Removal of Ozone

Ozone Formation:

$$O_2 + h\nu \rightarrow 2\,O^* \ldots\ldots\ldots\ldots\ldots\ (\lambda < 240\text{ nm})$$

$$O^* + O_2 \rightarrow O_3$$

Ozone Removal:

$$O_3 + h\nu \rightarrow O^* + O_2 \ldots\ldots\ldots\ldots\ (200\text{ nm} < \lambda < 310)$$

$$O_3 + O^* \rightarrow 2\,O_2$$

Catalytic Ozone Removal (by Cl, Br, OH^*, NO^*):

The catalysts can be anthropogenic or natural

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + O_3 \rightarrow Cl + 2\,O_2 \ldots\text{..catalyst regenerated.}$$

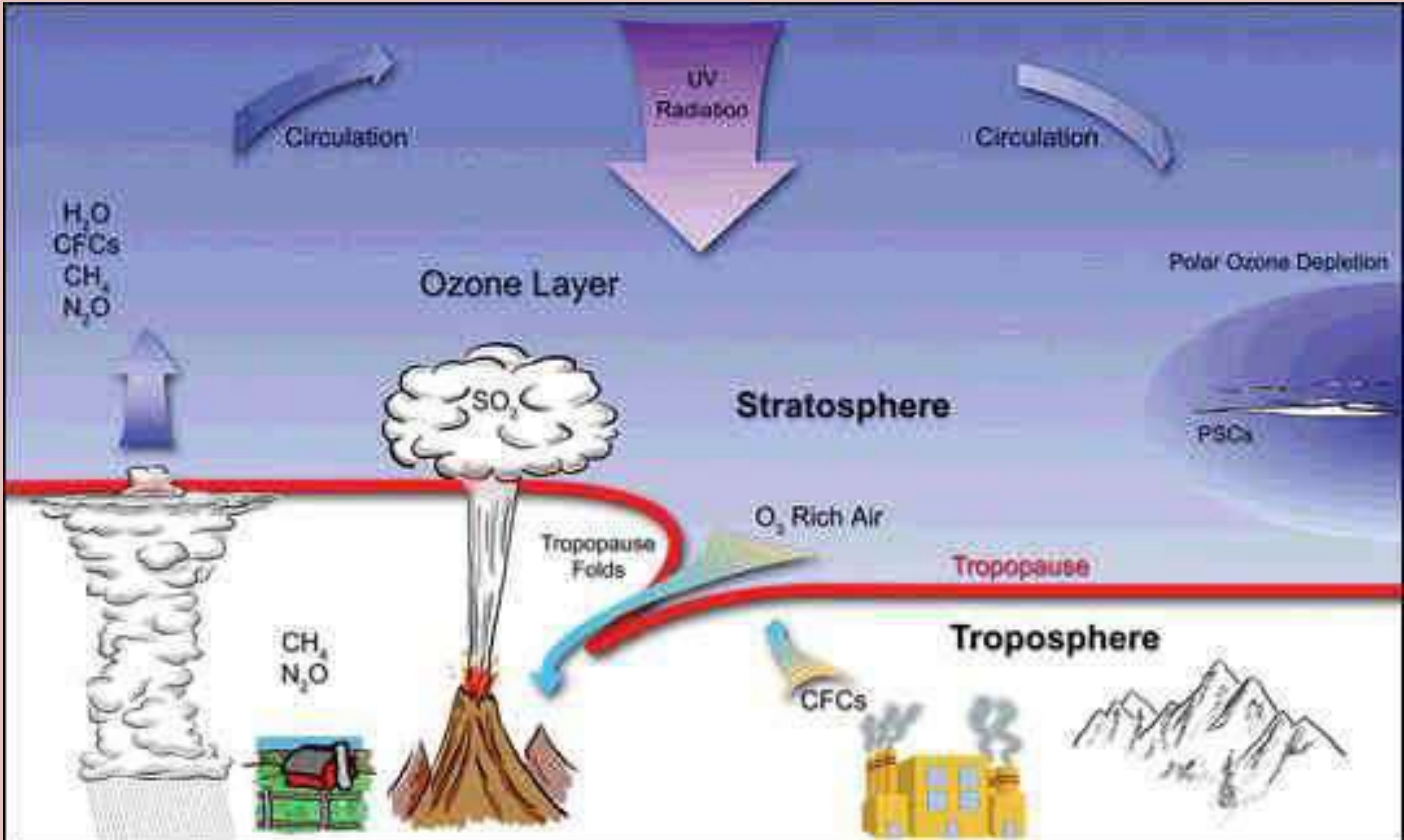
Anthropogenic Ozone Depletion

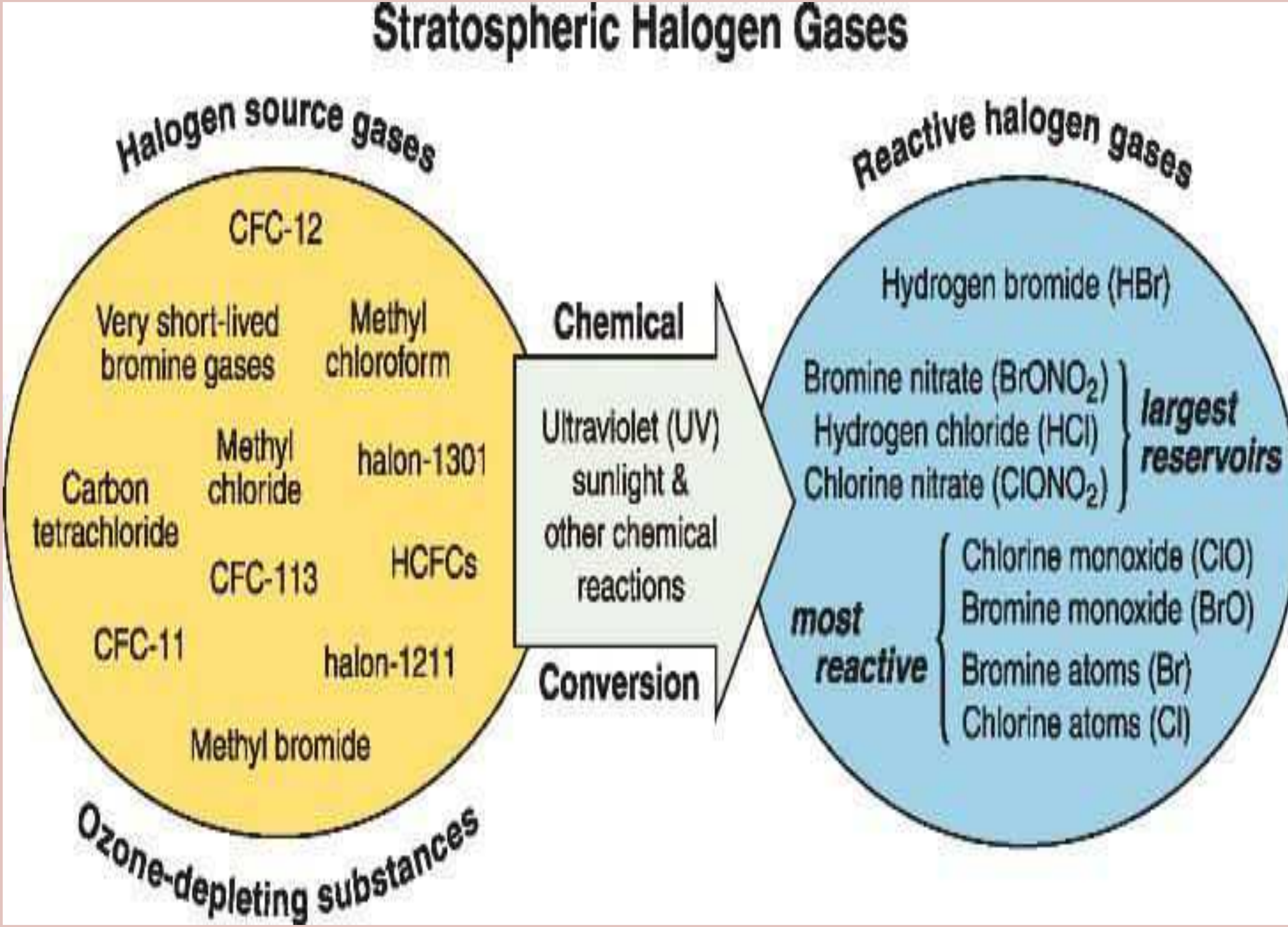
- Emission of chlorofluorocarbons and other ozone depleting substances.
- These molecules are inert and non water soluble,
- They are not destroyed through atmospheric chemical reactions in the troposphere or removed with precipitation.
- They rise to the stratosphere and are broken down to yield Cl, Br. e.g.

$$CFCl_3 + h\nu \rightarrow CFCl_2 + Cl$$

- This results in a drastically higher concentration of ozone-destroying catalysts (Cl, Br) in the stratosphere.
- Accelerates the catalytic destruction of ozone.
- A single chlorine molecule can break down tens of thousands of ozone molecules before it gets deactivated.

Ozone Depletion




Stratospheric Halogen Gases
Halogen source gases
CFC-12
Very short-lived bromine gases
Methyl chloroform
Methyl chloride
halon-1301
Carbon tetrachloride
CFC-113
HCFCs
CFC-11
halon-1211
Methyl bromide
Ozone-depleting substances
Chemical
Ultraviolet (UV) sunlight & other chemical reactions
Conversion
Reactive halogen gases
Hydrogen bromide (HBr)
Bromine nitrate ($BrONO_2$)
Hydrogen chloride (HCl)
Chlorine nitrate ($ClONO_2$)
largest reservoirs
Chlorine monoxide (ClO)
Bromine monoxide (BrO)
Bromine atoms (Br)
Chlorine atoms (Cl)
most reactive

Chemical	Application	O_3 Dep. Pot.
CFC	Stable in troposphere. Rise to the stratosphere, break down in presence of UV-B and attack O_3.	0.6-1
CCl_4	Wide industrial uses: CFC manufacture, solvent and catalyst. Potent carcinogen.	1.2.
Halons	Contain Br, F, C. Fire extinguishing agent. Production Stopped in the U.S. ended on 12/31/93. Br is many times more effective at destroying ozone than Cl	
HCFC	CFC-replacements. Lesser depletion potential.	0.01- 0.1.
HFC	CFC replacements. Because they do not contain chlorine or bromine, they do not deplete the ozone layer.	0.
MeBr	CH_3Br Methyl Bromide. Pesticide for soil and many agricultural products. Production stopped in the U.S. on 12/31/2000.	0.6.
CH_3CCl_3	Methyl Chloroform. Industrial solvent.	0.11.
HBFC	Hydrobromofluorocarbon Class I substances.	

Chlorofluorocarbons

- CFCs can last in stratosphere > 100 yr.
- Production ban since December 31, 1995.
- Only recycled and stockpiled CFCs can now be used on a limited basis.
- CFCs are also a "greenhouse gas"
- Class I substances have an ozone-depletion potential of 0.2 or higher. These include CFCs, halons, carbon tetrachloride, methyl chloroform, HBFC and methyl bromide.

Hydrochlorofluorocarbons

- HCFCs and hydroflurocarbons (HFC) are safer.
- Less stable in the atmosphere
- Less likely to reach the stratosphere to affect the ozone layer.
- HFCs even lack Cl and hence are safer.
- But HCFCs an HFCs are highly potent greenhouse gasses.

Measurement of Ozone: Dobson Unit

- Measurement of stratospheric ozone columnar density: Dobson unit (DU)
  - Gordon Dobson, University of Oxford researcher.
  - 1920s, he built the Dobson ozone spectrophotometer.
- 1 DU = a layer of ozone that would be 10 µm thick under standard temperature and pressure. 2.69×10^{16} ozone molecules/ sq. cm
- 300 DU of ozone brought down to the surface of the Earth (atmospheric pressure) at 0°C would occupy a layer only 3 mm thick.
- Ozone hole: Layer < 220 DU

Global warming and Ozone – Depletion impacts of CFCs

- Fully halogenated CFCs have long atmospheric lifetimes,
- They contain relatively large amounts of chlorine
- They absorb strongly within the 7 to 13 micron atmospheric window
- Therefore, they have considerable potential for both global warming and ozone depletion.
- **They are 15000 times potent than carbon dioxide when compared to carbon dioxide!**

India & CFC's

- According to UNEP, in 2008, India produced almost all the CFC in the world, and the amount it officially exported was far lower than the amount reported by other countries to be imported from India.
- However, CFC's are still the most smuggled commodity, next to drugs.
- India and South Korea are the two major manufacturers that still produce CFC's, but are sold on the black market.

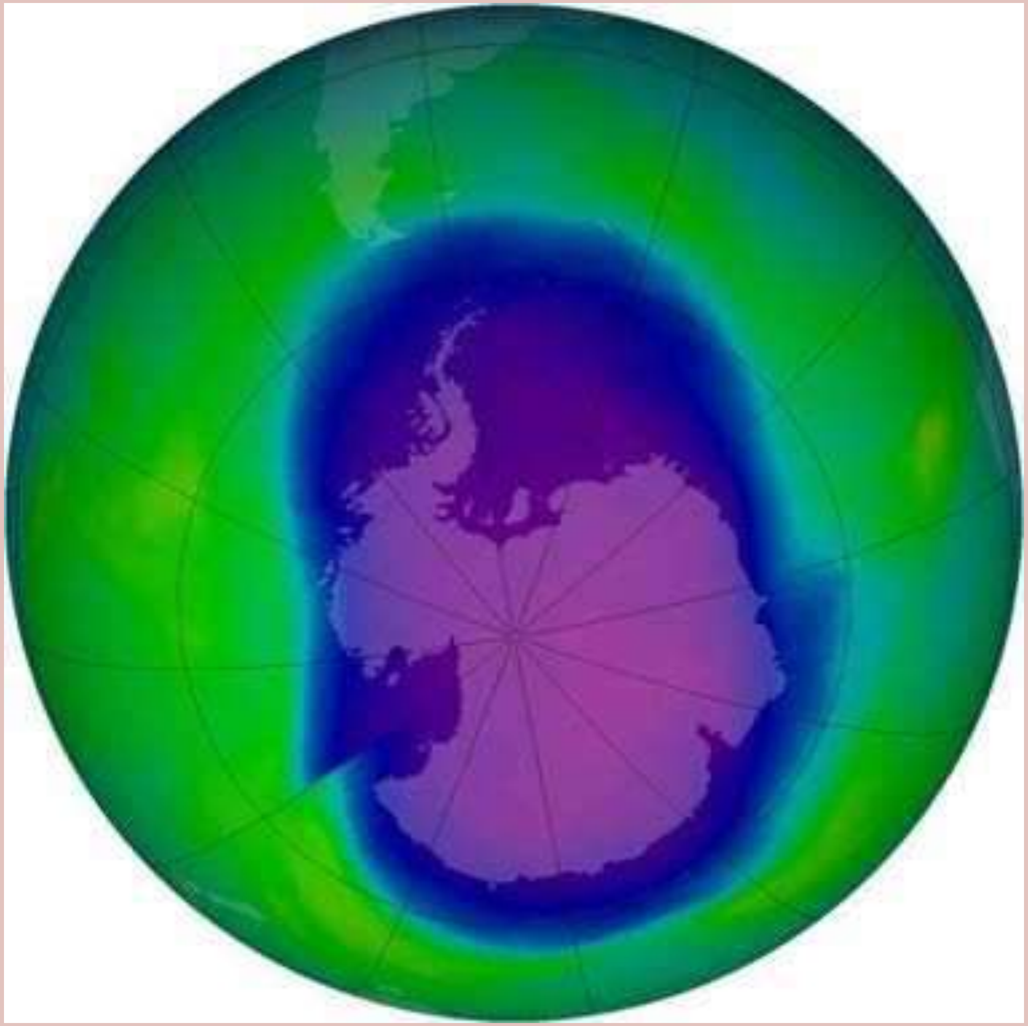
- In 2008, UNEP estimated these two countries accounted for over 70 per cent of global CFC production, which has come down from a million tonnes a year to 50,000.
- All developed nations have already banned CFC production, and India officially banned CFC's in late 2008, after signing the Montreal Protocol.

Homogenous and Heterogeneous Ozone Depletion

- Homogeneous:
    - the depletion occuring more or less uniformly all over the globe (in the statosphere.
- Heterogeneous: Ozone hole
    - Excessive depletion of the ozone layer above the poles especially during the spring season.

(http://www.epa.gov/ozone/science/hole/whyant.html)

Ozone Hole



Largest observed ozone hole, September 21-30 Sept, 2006 (10.6 mi. sq miles). The blue and purple colors are where there is the least ozone, and the greens, yellows, and reds are where there is more ozone. Credit: NASA

Watch NASA video on Ozone Depletion

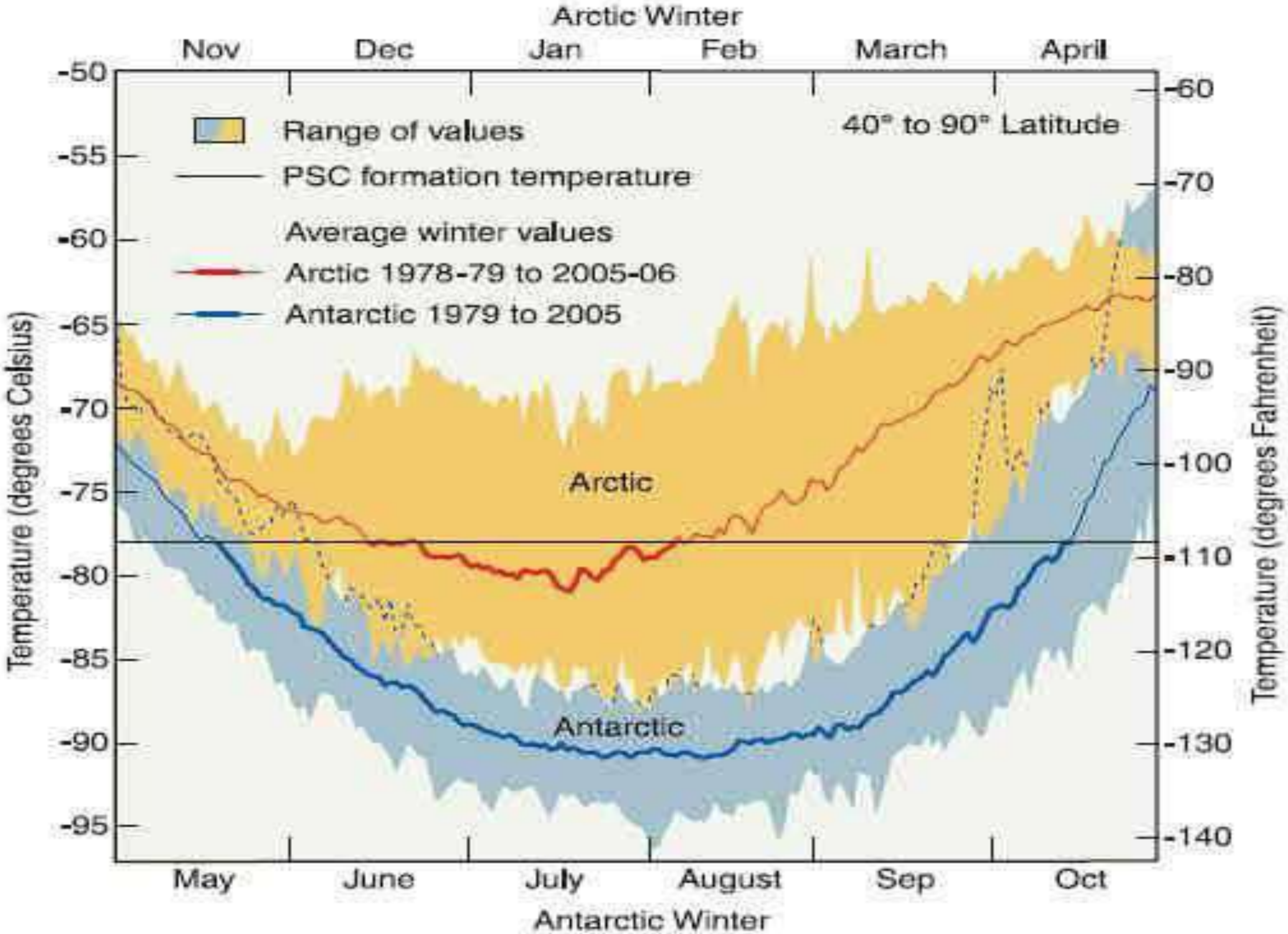
Antarctic Ozone Hole

- In the 3-month long dark polar winter, **the Polar Vortex develop** (http://science.nasa.gov/headlines/y2000/ast02oct_1.htm)
- It is more pronounced in the southern hemisphere due to fewer land masses.
- It traps and chills the polar stratosphere to <–80 °C.
- **Polar Stratospheric Clouds (PSCs)** form at these temperatures.
- Chlorine accumulates on these ice crystals in the form of reservoir compounds like **$ClONO_2$, HOCl**

$$Cl + O_3 \rightarrow ClO + O_2$$

$$ClO + NO_2 \rightarrow ClONO_2$$

Minimum Air temperatures in the Polar Lower Stratosphere

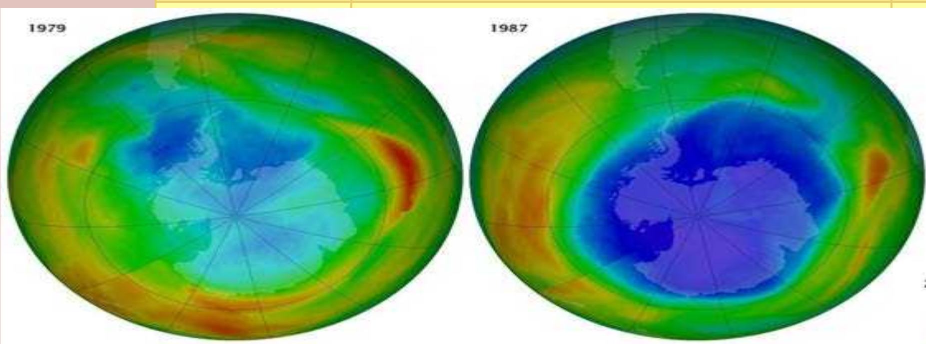


Antarctic Ozone Hole

- In the spring, solar radiation triggers the release of massive quantities of Cl from the reservoir compounds.
- The released Cl causes a rapid catalytic degradation of ozone in a short span.
- This leads to the formation of the ozone hole.
- By mid-December (in the Antarctic), the polar vortex breaks up, PSCs disappear, and ozone from lower latitudes comes in and the ozone hole shuts down.

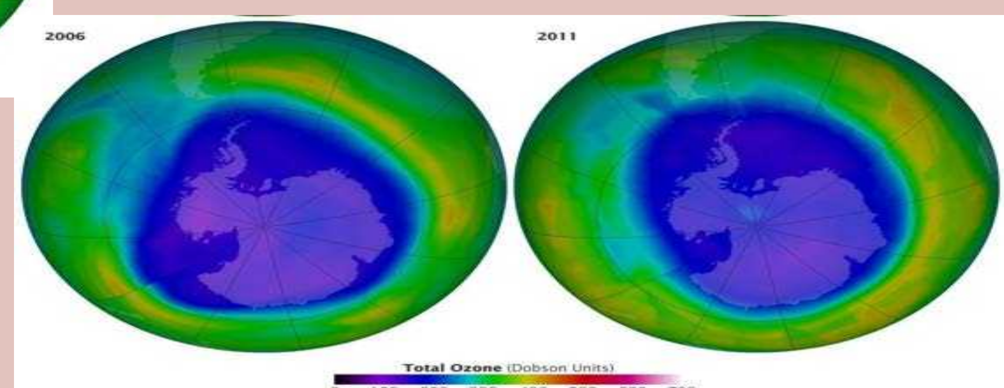
Temporal status of Ozone

Year	Area of O_3 Hole (in million km^2)	Concentration of O_3 (in DU)
1979	11.1	194
1987	22.4	109
2006	29.6	84
[illegible]	[illegible]	95



Credit: https://earthobservatory.nasa.gov/IOTD/view.php?id=79198

Images by NASA on the status of the Antarctic Ozone Hole on September 16 of the years 1979,1987,2006& 2011



Montreal Protocol on Substances that Deplete the Ozone Layer

- International treaty with a mission to protect Ozone layer by regulating production of ozone-depleting substances (ODSs)

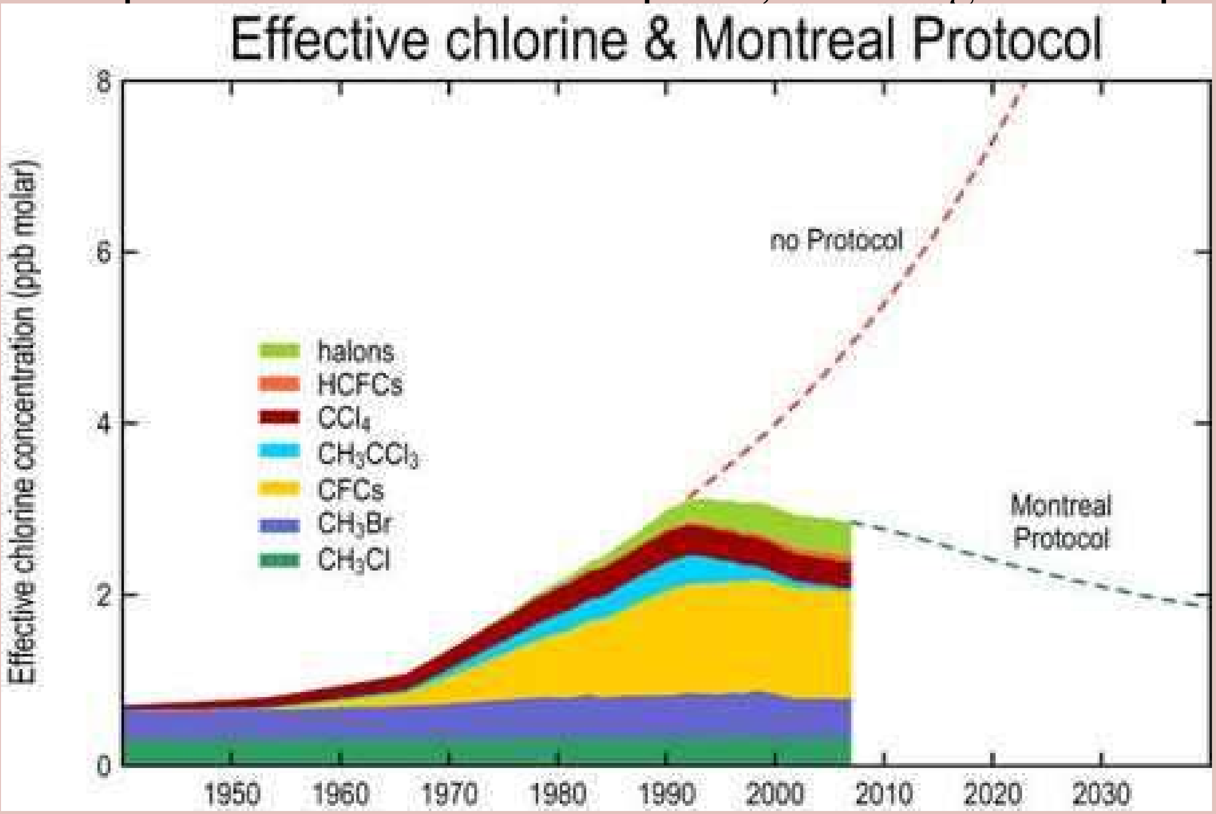
- It was initiated on 16 September 1987, and entered into force on 1 January 1989; 197 countries participated in the ratification process thereafter

- It is believed that if the international agreement is adhered to, the ozone layer is expected to recover by 2050.

"Perhaps the single most successful international environmental agreement to date has been the Montreal Protocol" Kofi Annan (Former Secretary-General of the United Nations)

How has the Montreal Protocol been a success story?

The treaty with the international cooperation has effectively phased-out the production and consumption of several major Ozone Depleting Substances (ODSs) in the lower atmosphere and in the stratosphere, enabling staratospheric ozone recovery.

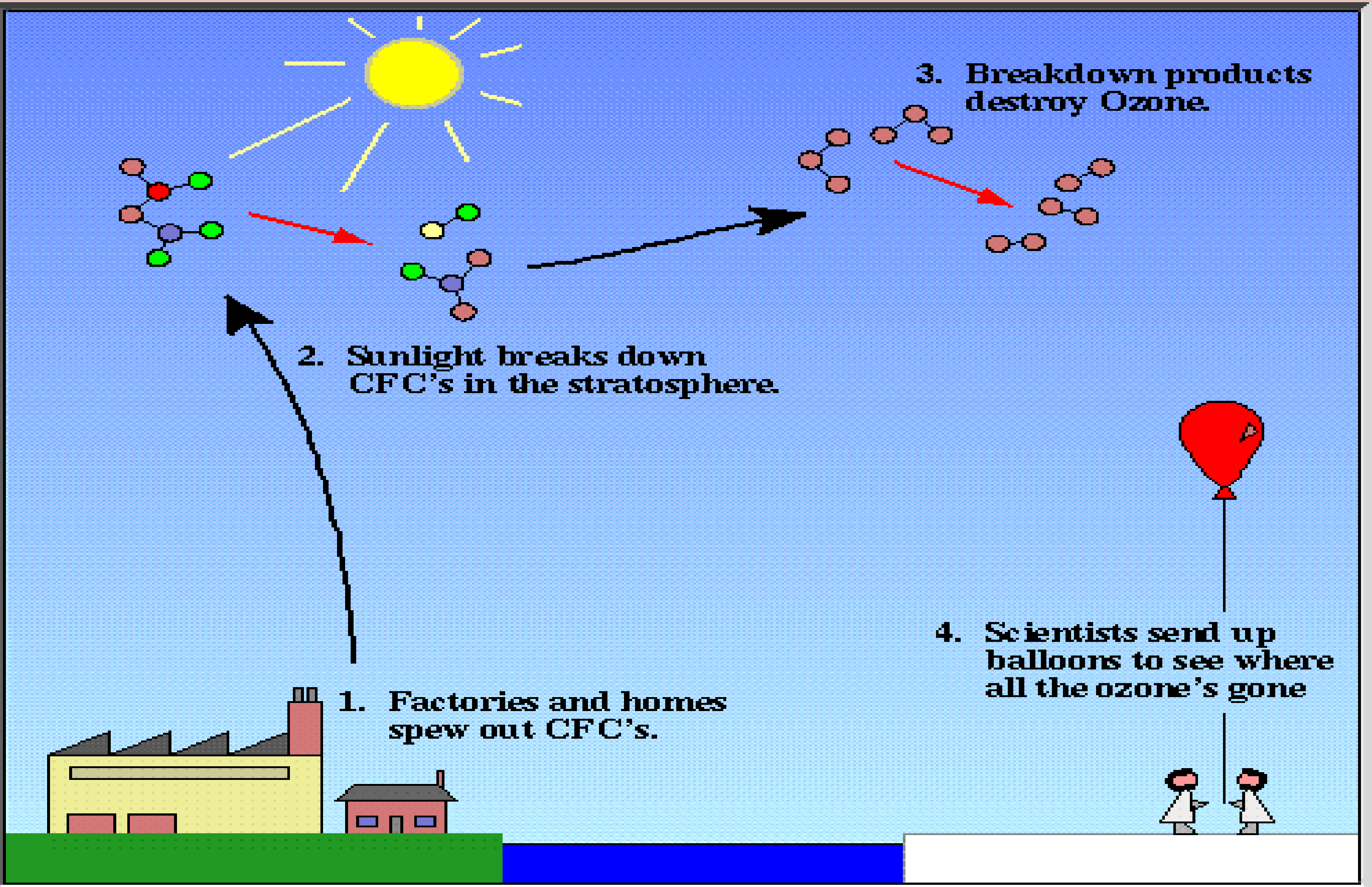


Graphical illustration by CSIRO Marine and Atmosphere Research on global impact of the Montreal Protocol on the levels of ODSs in the atmosphere, and suggest the impact by 2050

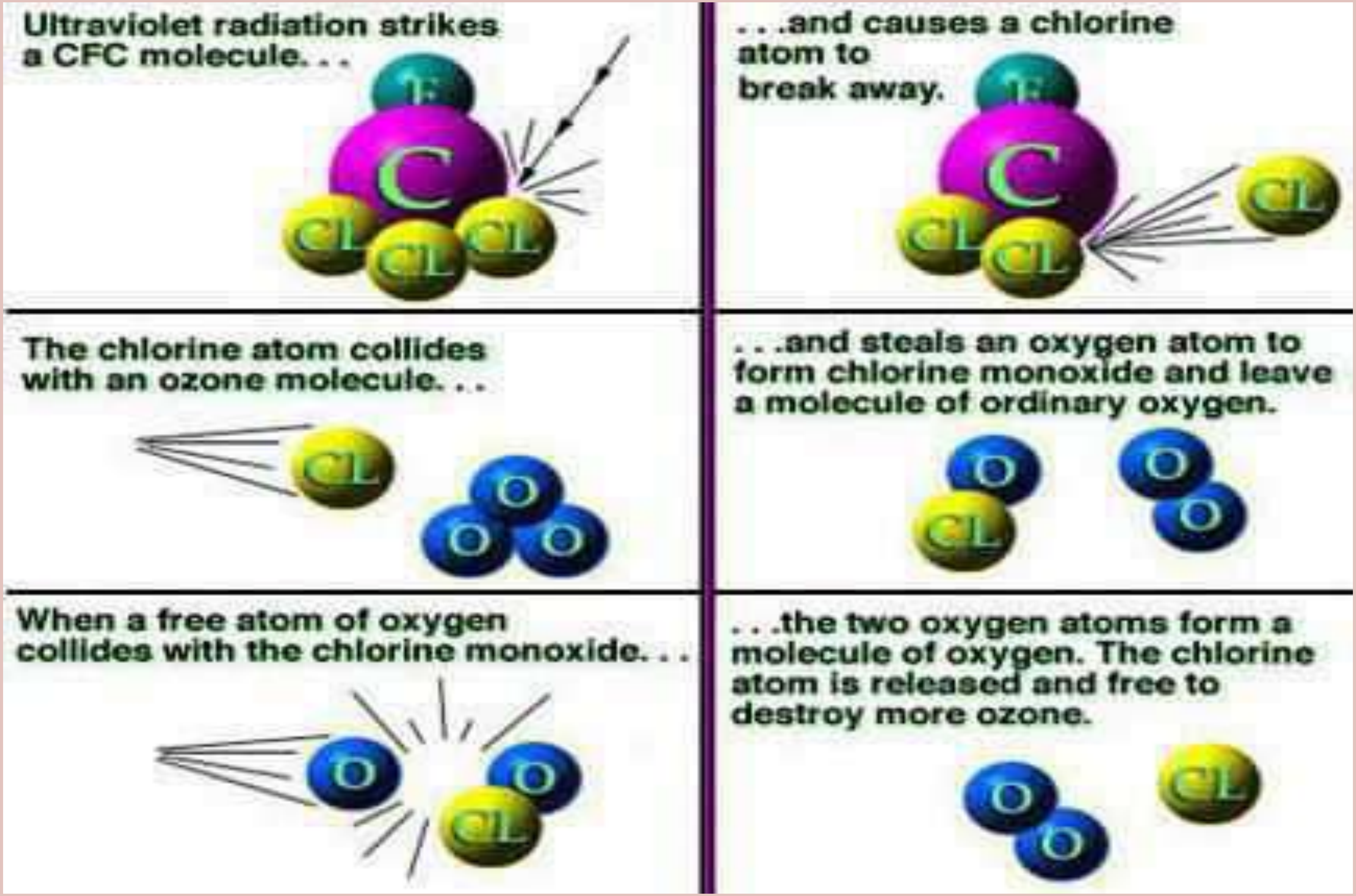
Never doubt that a small group of thoughtful, committed citizens can change the world indeed it’s the only thing that ever has

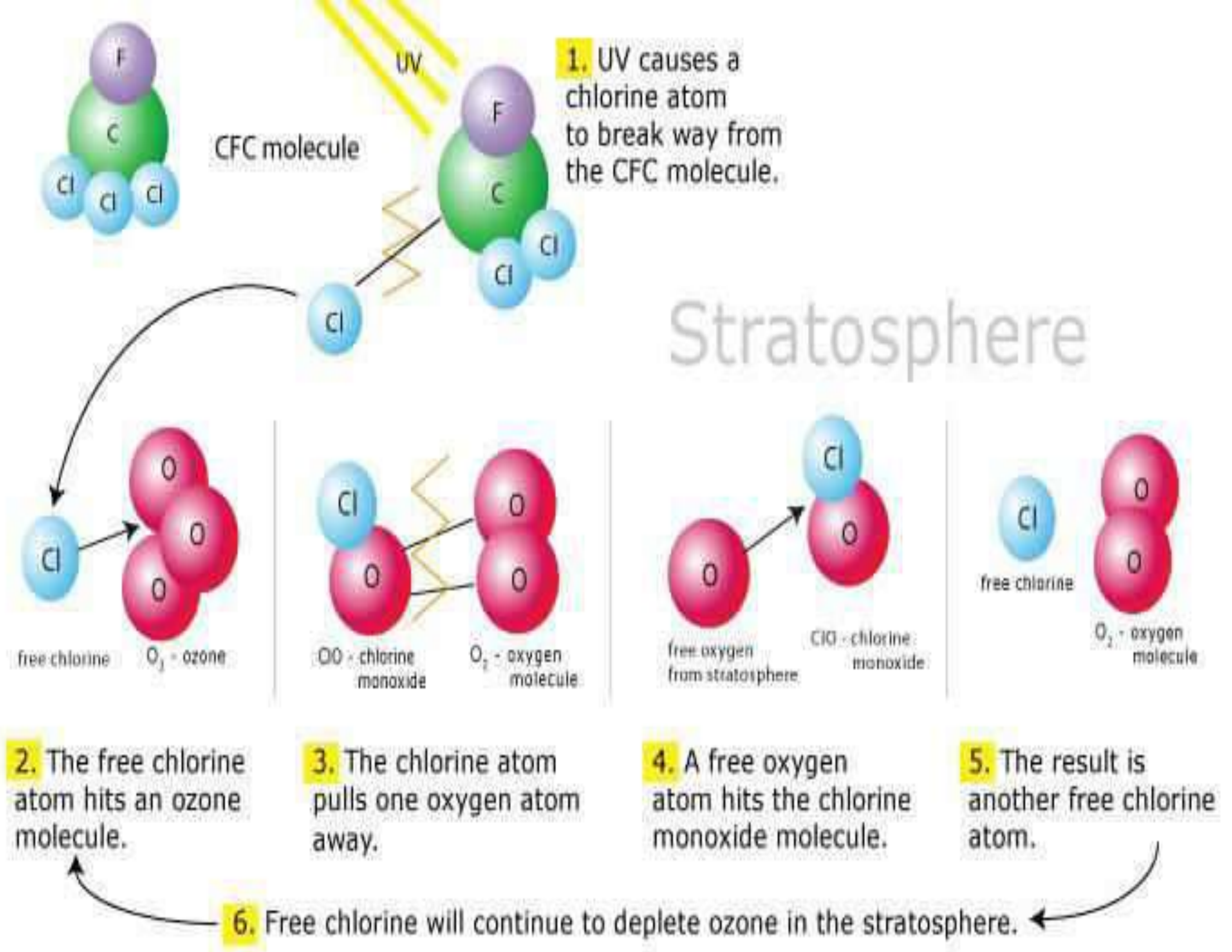
- Margaret Meed

Extra slides



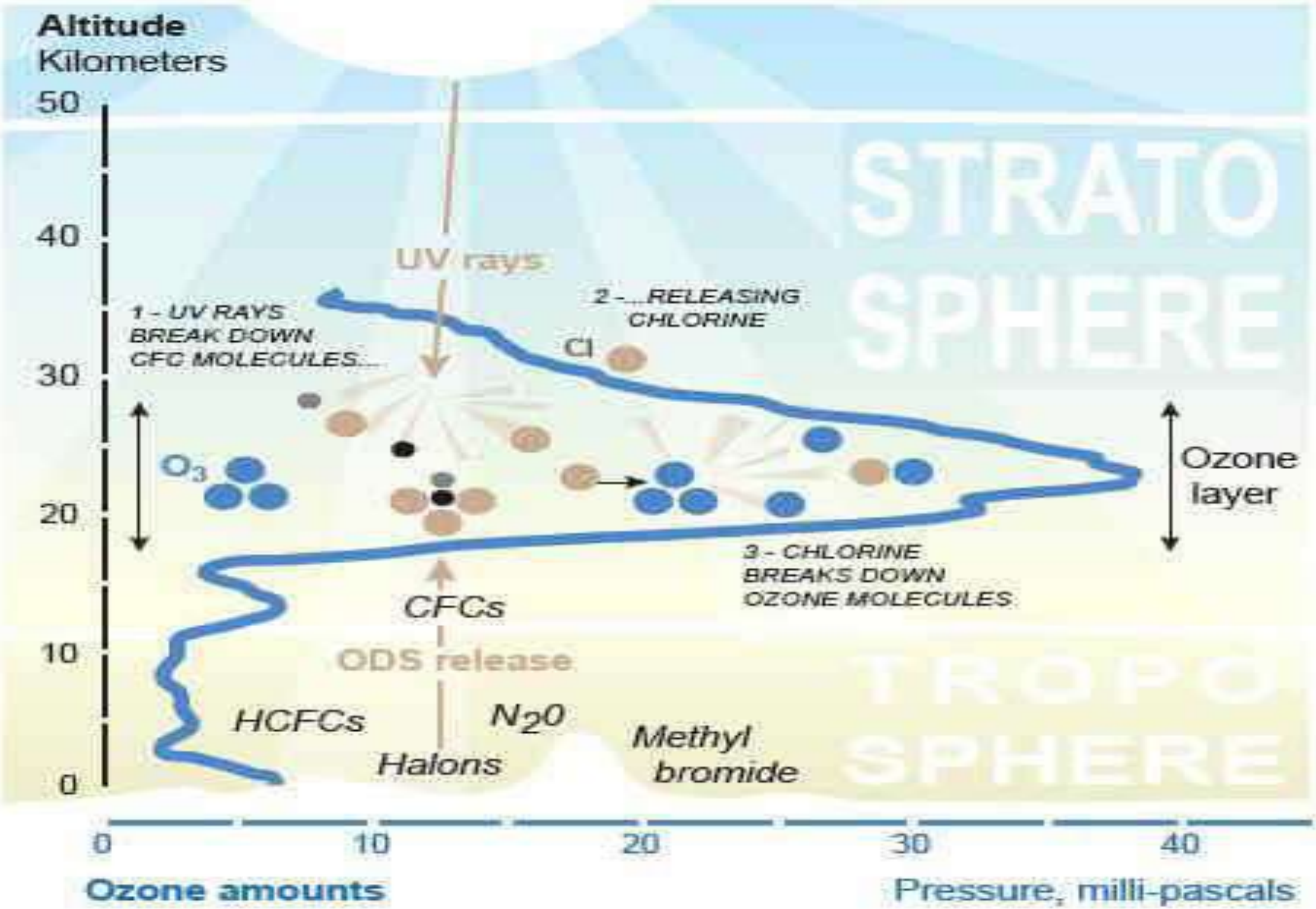
How ozone is destroyed by CFCs





1. UV causes a chlorine atom to break way from the CFC molecule.
UV
CFC molecule
F
C
Cl
Stratosphere
free chlorine
O_3 - ozone
ClO - chlorine monoxide
O_2 - oxygen molecule
free oxygen from stratosphere
ClO - chlorine monoxide
free chlorine
O_2 - oxygen molecule
2. The free chlorine atom hits an ozone molecule.
3. The chlorine atom pulls one oxygen atom away.
4. A free oxygen atom hits the chlorine monoxide molecule.
5. The result is another free chlorine atom.
6. Free chlorine will continue to deplete ozone in the stratosphere.

CHEMICAL OZONE DESTRUCTION PROCESS IN THE STRATOSPHERE



Ozone layer as protective shield

Atomic oxygen is produced by the photolytic decomposition of molecular oxygen

$$O_2 + h\nu \longrightarrow O + O$$

Atomic oxygen, in turn, reacts rapidly with molecular oxygen to form ozone

$$O + O_2 + M \longrightarrow O_3 + M$$

where M represents a third atom (Nitrogen or oxygen)

- Ozone removal by photo dissociation

$$O_3 + h\nu \longrightarrow O_2 + O$$

$$H_2O + ClONO_2 \longrightarrow HOCl + HNO_3$$

The sun light frees Cl from HOCl by photolysis

$$HOCl + h\upsilon \longrightarrow Cl + OH$$

$$Cl + O_3 \longrightarrow ClO + O_2$$

$$OH + O_3 \longrightarrow HO_2 + O_2$$

Impacts of other greenhouse gases

Methane helps to remove ozone destroying chlorine

$$Cl + CH_4 \longrightarrow HCl + CH_3$$

$$CH_3 + O_2 \longrightarrow CH_3O_2$$

$$CH_3O_2 + NO \longrightarrow CH_3O + NO_2$$

$$NO_2 + h\upsilon \longrightarrow NO + O$$

$$M + O + O_2 \longrightarrow O_3 + M$$

Water Resource Management

Outline

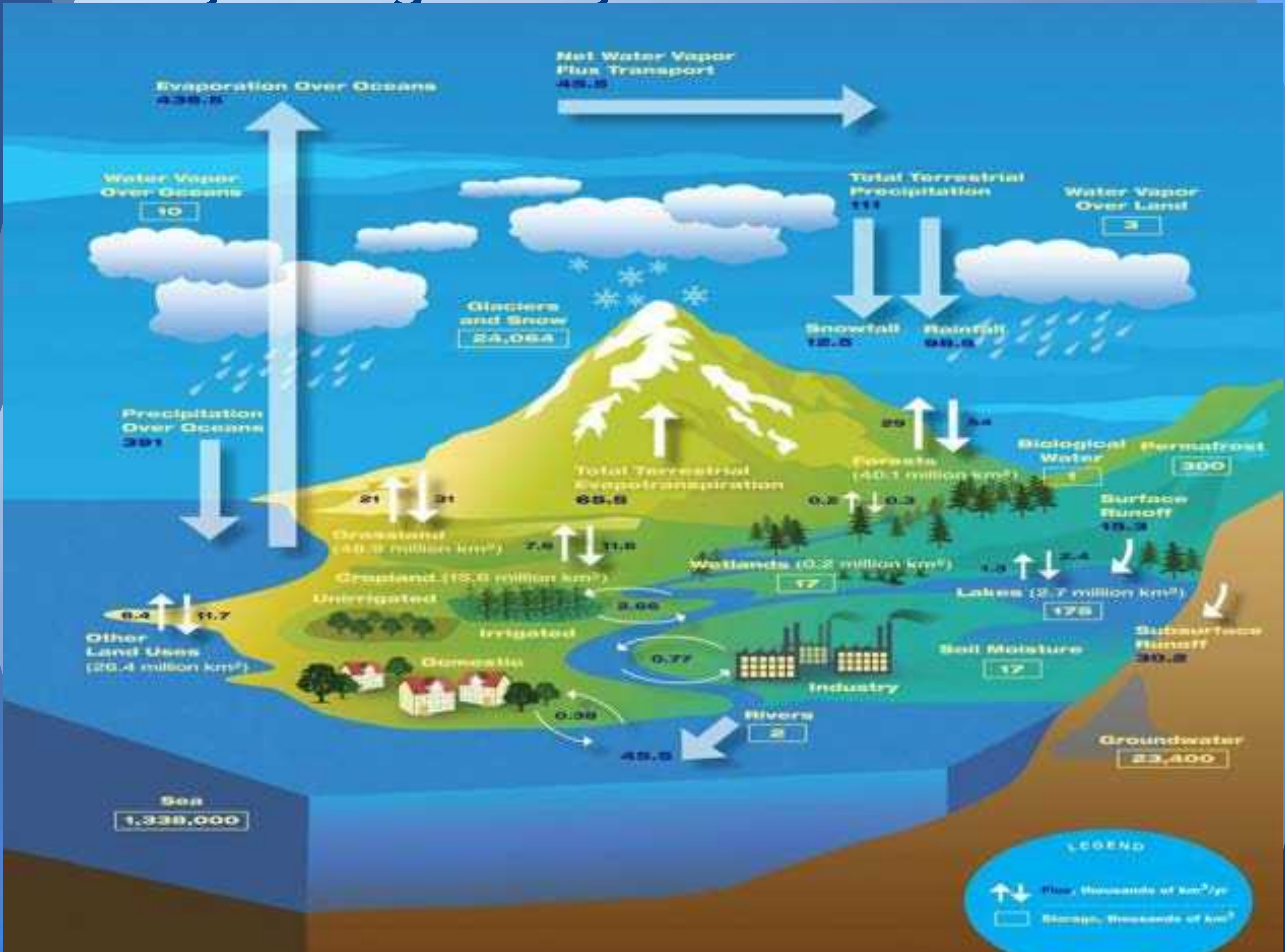
- Water Cycle
- India's Water Crisis: Depleting resources, pollution, dams agitations, scarcity.
- Sustainable Solutions
  - Supply Side
    - Rainwater Harvesting
    - Watershed Management
  - Demand Side
    - Conservation in Agriculture
    - Conservation in Industry
    - Conservation in Domestic Use

Water Cycle

Watch Video: The Water Cycle (6.46 min).

Credit: National Science Foundation, Directorate for Geosciences, Division of Earth Sciences. USA.
Source: https://www.youtube.com/watch?v=al-do-HGuIk

The Hydrological Cycle



Credit: NASA/JPL. Source: https://c1.staticflickr.com/9/8210/8264025043_58e1fbef57_h.jpg

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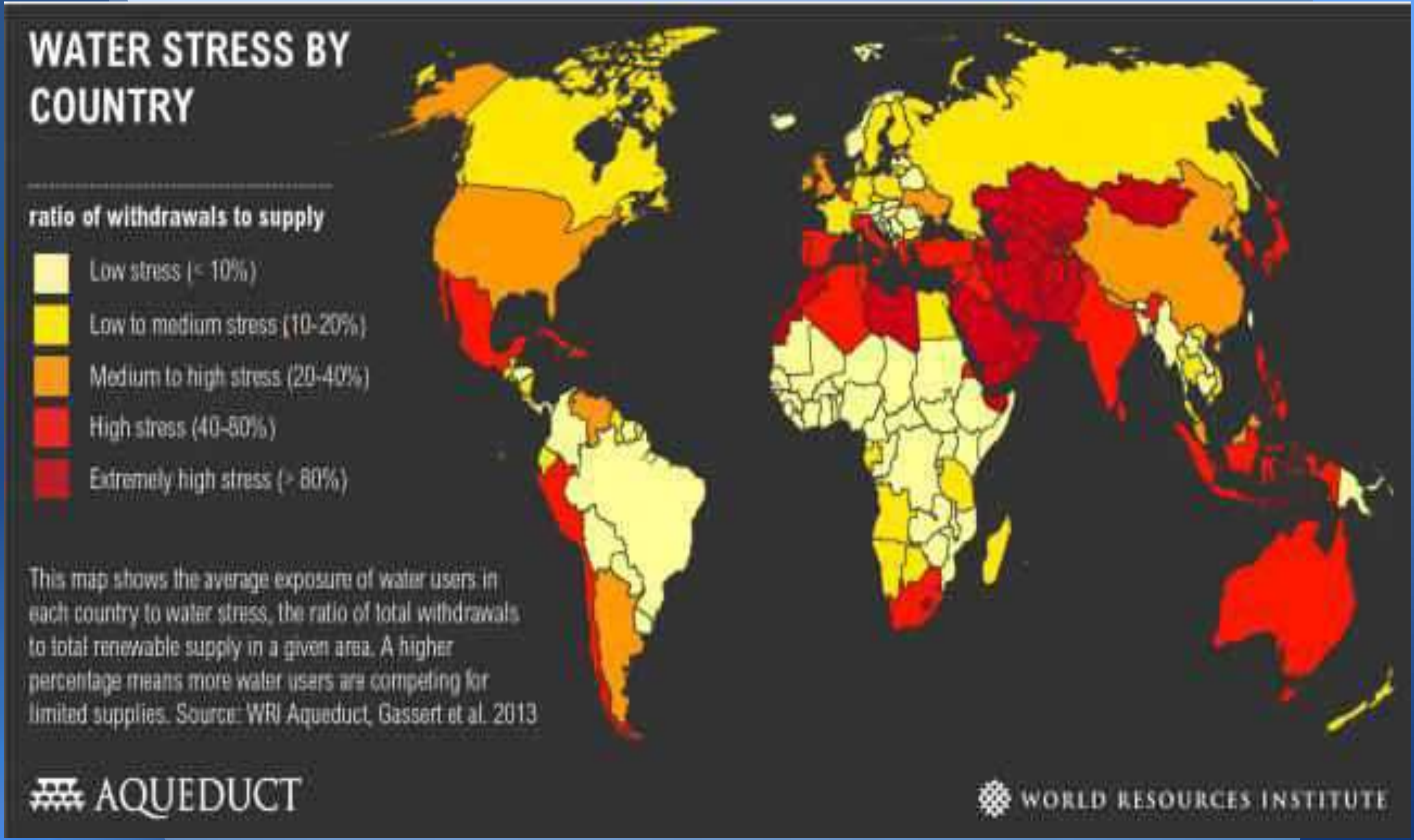
India's Water Availability

- Per capita availability of water is rapidly declining:
  - Yr. 1951: 5177 m^3/yr
  - Yr. 2001: 1816 m^3/yr
  - Yr. 2011: 1588 m^3/yr [ref]
- India is now a water-stressed country (<1700 m^3/yr per capita)
- 128 mi. lack safe water
- More than 60,000 villages without a source of drinking water.

Water-Stressed India



http://www.wri.org/resources/charts-graphs/water-stress-country

Why can't we build more dams to increase water supply?

Dammed Rivers--Damned Lives

- Unacceptable socio-environmental impacts [ref]
  - Unfavorable benefit:cost ratio
  - Large scale displacements of populations; poor compensation
  - Disproportionate share of losses borne by people who enjoy little benefits.
  - Downstream impacts unaccounted.
  - Reduced sediment and freshwater discharge to floodplains, riverine and estuarine ecosystems.
  - Severe disruptions in migratory fauna.
- Major people's agitations

Related Reading Material

World Commission on Dams - Dams and Development Project

Report of the World Commission on Dams – UNEP

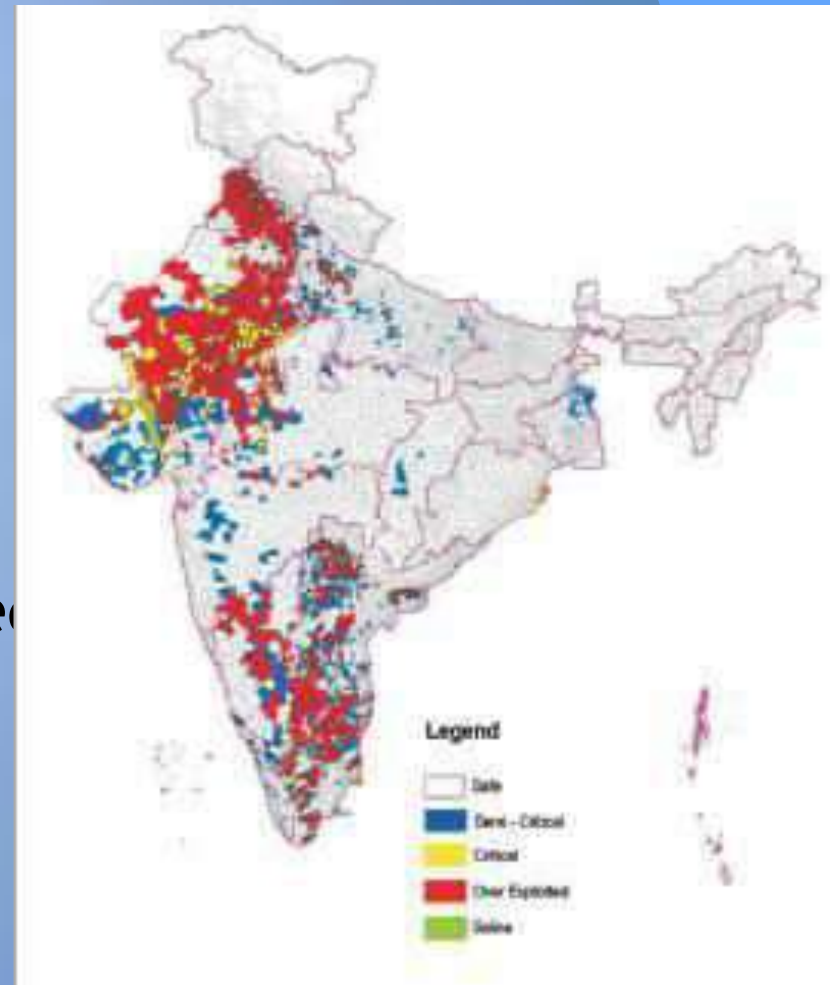
A Brief Introduction To The Narmada Issue

http://www.internationalrivers.org/

Why can’t we drill more borewells to increase water supply?

India's Groundwater Depletion

- Groundwater
  - Feeds 50-75% of agriculture land
  - 600 mi. overly depend on it. [ref]
  - >90% of it is used for agriculture [ref]
  - 60% will be critically degrade in 20 yrs.[ref]
- Alarming depletion of groundwater
  - Mean rates: 4 cm/yr ($17 km^3/yr$)[ref]
  - Much higher rates locally.



Central Groundwater Board: http://www.cgwb.gov.in/
http://www.cgwb.gov.in/documents/Dynamic-GW-Resources-2004.pdf

Why not interlink the major rivers so that the excess water in one river can be diverted to other rivers which have a shortage?

Inter-linking of rivers

Claimed benefits of interlinking Indian rivers:

- No more droughts in the south
- No more floods in Ganga and Brahmaputra
- More power – 30,000 MW of hydropower will be generated

Inter-linking of rivers

- Budget Rs. 5600 to 10,000 billion
- Lowest estimate equals to 25 % of GDP, 2.5 times of our tax collection
- Funds to be raised from international sources
- Even if we succeed in raising funds annual interest alone would amount to Rs. 200-300 billion
- Water will have to priced high

Inter-linking of rivers

Issues

- People's and political willingness to share water
- Not yet clear whether rivers like Ganga, Brahmaputra, Mahanadi and Godavari are water surplus – as the sources of these rivers are drying up and rivers themselves choked with silt
- Ecological consequences of building over 200 reservoirs and network of canals cannot be assessed

Inter-linking of rivers

Issues

- Large quantity of electricity needed to pump enormous quantity of water over the elevated Deccan Plateau

Inter-linking of rivers

Issues

- Submergence of habitats, forests and fertile land
- Destruction of wildlife and biodiversity
- Displacement of large populations of people

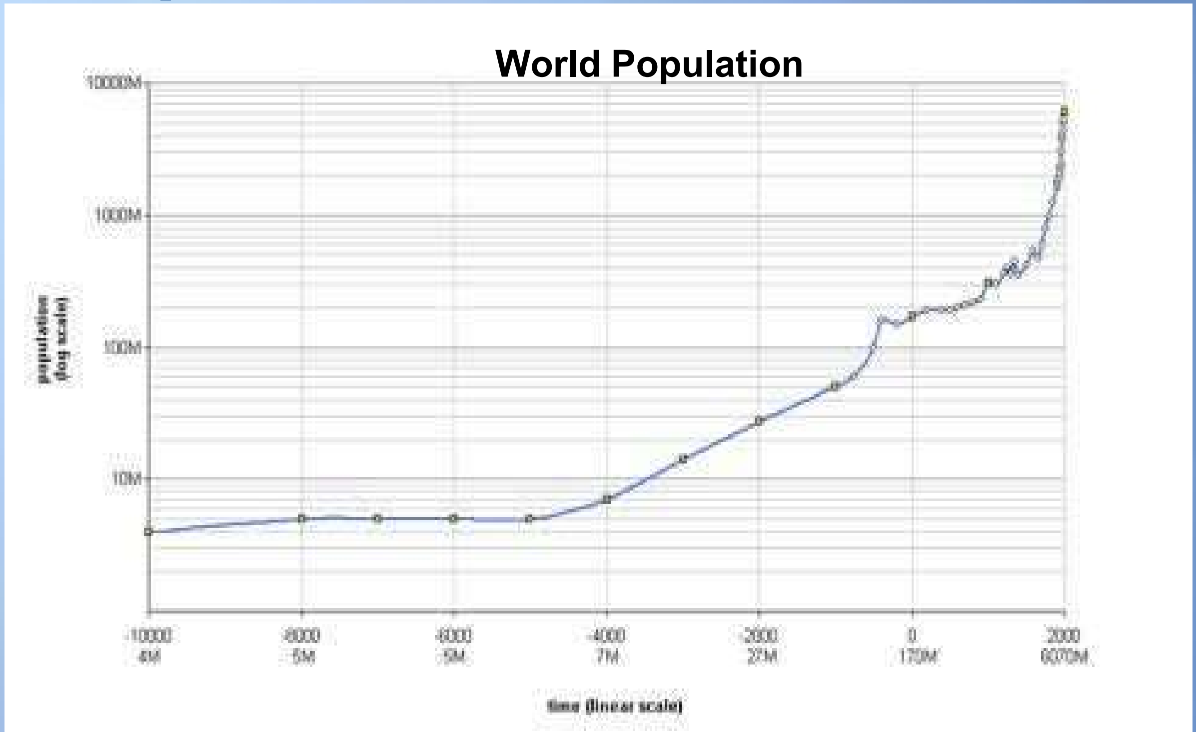
If water availability is reducing, why not reduce water use?

Complications: Food Crisis

- >78% water goes for agriculture.
  - Food for the growing population
  - Increased irrigation demands
  - >50% food comes from irrigated land (35% of arable land).
  - Yields of rainfed arable land (65% of total arable) low due to lack of irrigation and land degradation.
  - **Reducing water use directly conflicts with food production.**

But India is supposed to be the land of great rivers and lakes.
What has become of them?

India's Population Growth



Credit: Waldir. Source: http://en.wikipedia.org/wiki/Demographic_history

India's Population [ref]

- 1950: 359.0 mi.
- 2014: 1238.9 mi.
- India has some of the highest population densities in the world.

India's Water Pollution

- >70% of India's surface water resources are polluted by sewage and toxic chemicals [ref]
- Sewage treatment facilities in towns and cities:
  - Full facilities in only 8 cities[ref]
  - Partial facilities in 209 (6.7%) out of 3,119.
  - Over 114 Indian cities dumping untreated sewage and partially cremated bodies directly into the Ganges. [ref]

Tannery Waste Containing Chromium Dumped in the Ganges

India's Sewage Treatment

- Installed sewage treatment capacity in India's Class I cities and Class II towns in 2008: [ref] [ref]
    - Only 31.3% (11787 MLD) of total sewage generated (38254 MLD).
    - i.e. 68.7% of sewage is discharged untreated
- Treatment is virtually nonexistent in smaller towns

If the water is polluted, we must provide purified drinking water to all

- Purifying heavily polluted water is expensive!
- Contaminants can include, particulates, dissolved (ionic) impurities, biological contaminants, heavy metals and organic chemicals.
- The cheaper methods of drinking water treatment are often inadequate to remove all the above contaminants.
- The more comprehensive and sophisticated methods are expensive.
- The poorest in the country are hardest-hit by poor water quality.

DRINKING WATER SPECIFICATION: IS: 10500, 1992

WHO Guidelines for drinking-water quality

WHO Guidelines for Recreational, or bathing, waters

Then let's develop innovative cheap water filters or some other technology to purify water.

- Firstly, purifying heavily polluted water is not cheap.
- Besides, this simplistic approach completely misses the complexity of the issue.
- Uncontrolled pollution and depletion of water resources and mismanagement of wastewater are also part of the problem. The solution should give consideration to all these aspects.
- It means we must first understand these aspects adequately...

Come on! There’s no need to panic...Indians have a tough immune system...our bodies can surely handle a little water contamination...

Health Effects of Water Pollution

- Water, sanitation, and hygiene-related deaths: 0.4 mi./yr. (WHO 2007).
- The socio-economic costs of water pollution are extremely high: 1.5 mi./yr. children (<5 yrs.) die due to water related diseases,
- 200 mi. person-days of work are lost each year in India.
- National loss of INR 366 bi./year due to water related diseases (Parikh 2004).

http://www.idfc.com/pdf/report/2011/Chp-19-Water-Pollution-in-India-An-Economic-Appraisal.pdf

" No single measure would do more to reduce disease and save lives in the developing world than bringing safe water and adequate sanitation to all."

- UN Secretary General Kofi Annan

Ok, fine. How do the infections get into our drinking water anyway?

Through untreated sewage entering water sources

and

OPEN DEFECATION

Rain washes it all into our water bodies.

India's Sanitation

[ref]	Urban	Rural	Total
Improved water supply	96%	84%	88%
Improved sanitation	54%	21%	31%

- No sanitation services for 839 mi.
- Open Defecation
  - India: >50% population (638 mi.)
  - Bangladesh and Brazil: 7%
  - China 4%

Providing Sanitation

- Improved water supply and sanitation increases water demand
  - But supply is already short of the demand.
- It also increases the sewage to be treated
  - Installed treatment capacity is already far short of the requirement.

So the solution is simple: simply provide modern sanitation to all.

Then let's treat all the sewage with the well-established sewage treatment technologies.

Cost of Sewage Treatment

- Energy costs of treatment
  - Conventional: 320 KWh/ML [ref]
- Breakup of energy consumed
  - Aeration 60%
  - Anaerobic 11%
  - Pumping 12%

- Energy requirements for treatment
  - 9280 MWh/day (29000MLD x 320 KWh/ML with only 31% population having improved sanitation
  - 13,449 MWh/day if 100% population enjoys improved sanitation.

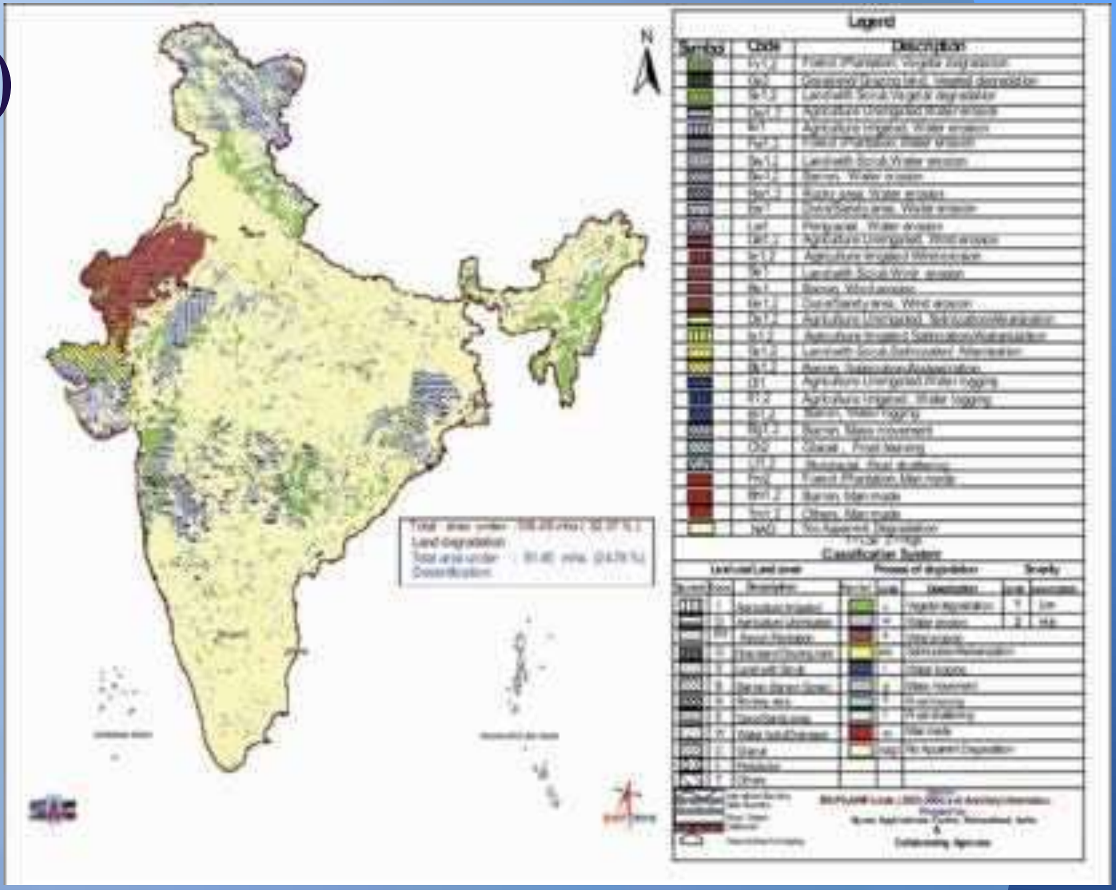
In a country undergoing an ENERGY CRISIS, how can we spend large amounts of power for treating sewage?

There are many other related complicating factors…

For instance, lack of irrigation is not the only reason for low agricultural productivity...

Complications: Land Degradation

- Land Degradation: 105 mi. ha (32.07%)
- Desertification 81.45 mi. ha (24.78%)
- Productivity loss of Rs. 28,500cr./yr
- Equivalent to 12% loss in total value productivity of these lands.
- Organic carbon inputs can be beneficial



Source: DESERTIFICATION & LAND DEGRADATION ATLAS OF INDIA Space Applications Centre (SAC), ISRO, 2007. http://www.moef.nic.in/sites/default/files/desert_atlas.pdf

Many socio-environmental problems are related to overcrowding and unplanned urbanization…
Bad governance is of course an important factor causing unsustainability...

So solving India's water crisis, is not going to be easy.

Activity: Water Quality in Nearby Sources

- Choose a nearby river, lake, or groundwater source.
- It may be conducted as a:
  - Field trip + Home Assignment
  - Home Assignment
  - Class Activity (by teacher providing necessary data).
- Have them fill out a form with the relevant information:
  - Use internet resources, newspaper clippings
  - Contact government bodies
  - Contact local NGOs working in the field of water.

  Compare it with IS: 10500 or **WHO Guidelines**
- Identify main water quality issues (eg. hardness, coliform organisms, specific contaminants etc.)
- Identify other issues (such as eutrophication, drying out, flooding, etc.) and their causes.

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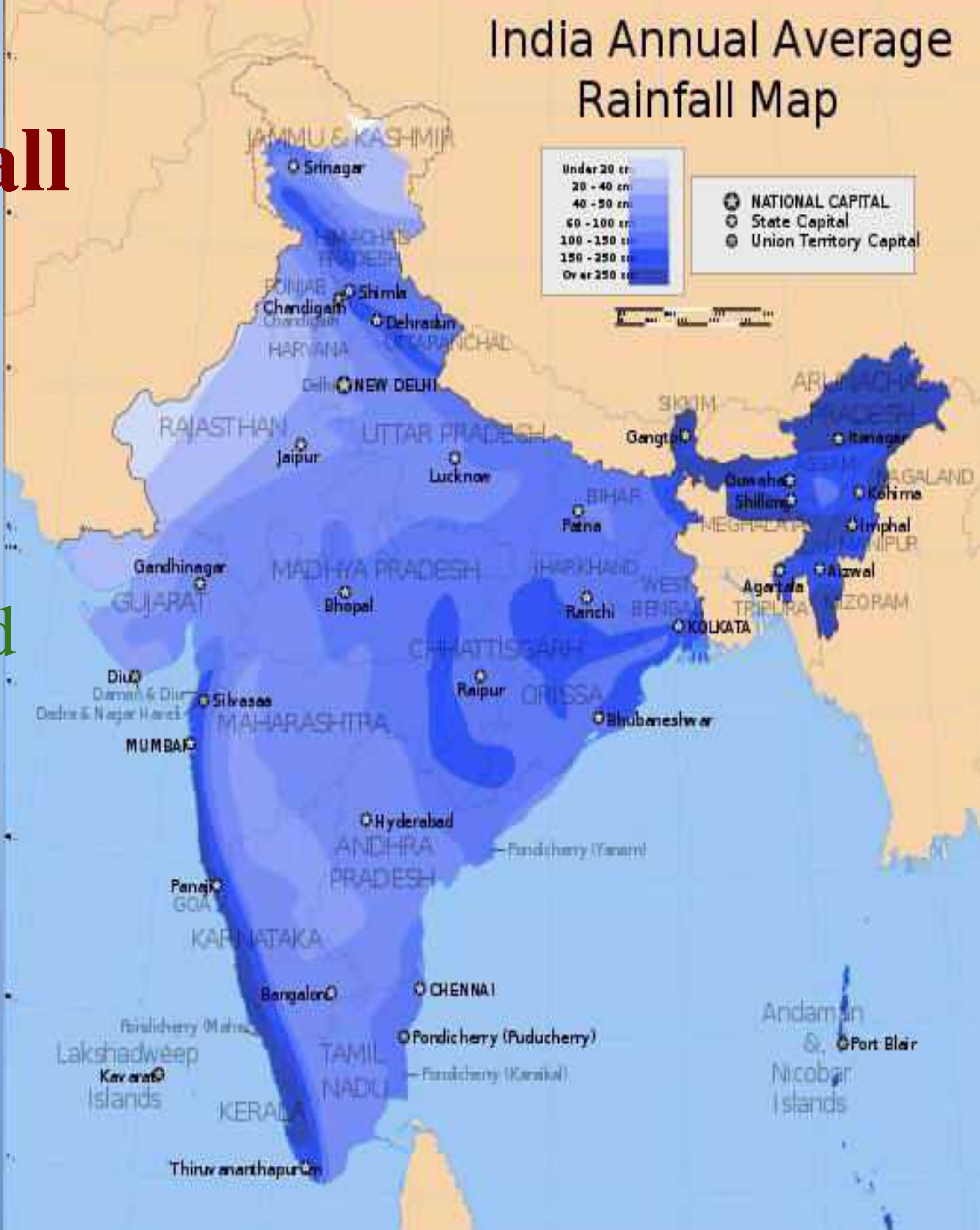
    - Conservation in Industry
    - Conservation in Domestic Use

Evolving Solutions

- Coordinated efforts from various sectors and agencies are required.
- Interventions in two areas required:
  - Making more water available (Supply side)
    - Rainwater Harvesting
    - Watershed Management
  - Using water efficiently, without polluting resources (Demand Side)
    - Agriculture
    - Industry
    - Domestic

India's Rainfall

- >80% of India gets at least 40 cm rain.
- Watershed management and rainwater harvesting is convenient for most places in India.



Solutions: Rainwater Harvesting

- Rainwater harvesting[ref] for **drinking water**
  - Need: 5 L/capita/day; **1825 L/capita/yr**
  - Collection: L/m^2/capita per cm of avg. annual rainfall.
  - Assuming >70% India gets at least 40 cm rain.
  - >70% population has more than 5 m^2/capita roof area
  - With 5 m^2 roof area and 40 cm rain, **2000L** can be collected.
  - Storage costs: Rs. 0.50-10/L (Rs. 1000-20,000/capita)
  - Cost reduction through community self-help.
  - Excess collected water to recharge aquifer through borewell or recharge wells.

Drinking Water: Collecting and Storing; Not Purification

- **Water purification to drinking standards**
  - Requires removal of hardness, dissolved organic and ionic contaminants, and disinfection.
  - High technology problem: desalination, ultrafiltration etc.
  - Cost reduction requires technological advances.
- **Collecting and storing (already clean) rainwater**
  - Low tech problem, with different cost options.
  - The lower cost options are communal storage, which involve the community owning up the responsibility to build and maintain the clean drinking water infrastructure.
  - More consistent with a sustainable community development.

Activity: Rainwater Harvesting for Your Home

- Calculate the total rooftop area for your family and per capita.
- Find out the average annual rainfall for your city
- Calculate the amount of rainwater falling on your roof that can be stored
  - Assume 20% losses (evaporation and first wash rejected).
- Design your own rainwater harvesting system, employing the local plumber.
- Calculate system cost.

Other high tech and high cost options to purify water may be used in the limited cases and regions, where rainwater harvesting is not possible.

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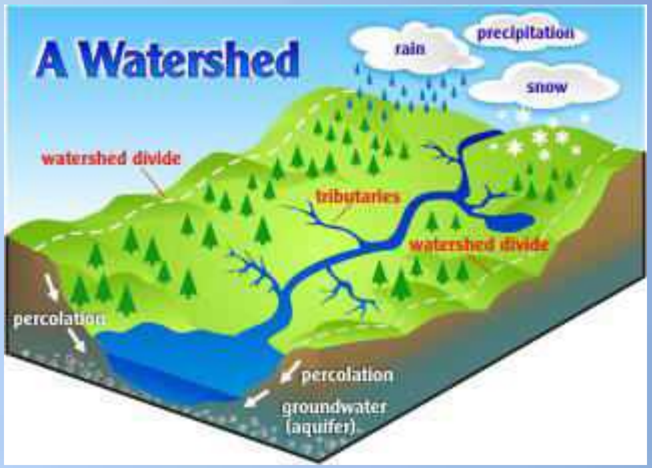
How to ensure that enough water is made available for all our other requirements?

Making More Water Available

- Water circulates in the biosphere through the Water Cycle.
- Water is directly useful for humans in only part of that cycle: from rainfall to until it flows to the sea.
- India's monsoon: 80% of rainfall in June-September [ref]
- Good management of water during this part can significantly increase both the quality and quantity of water available.
- This is called Watershed Management.
- Let's first try to understand what is meant by a Watershed.

Watershed



Credit: Pennsylvania Department of Environmental Protection. Source: http://www.portal.state.pa.us/portal/server.pt?open=514&objID=588795&mode=2

- The area from which all the water flows to the same place (larger river, lake or ocean.)
- It contains streams, rivers and underground flow.
- Smaller watersheds (the size of a village) are part of larger watersheds (size of states).
- Natural ecosystems (forests, wetlands) are part of the watershed.
- Our homes, roads, cities are part of some watershed.
- Pollutants are carried downstream with the water.

Slowing the Flow of Water

- The basic principle is to slow down the flow of water after rainfall.
  - Water flowing over the surface can reach the ocean in a matter of days...no water for the dry months.
  - Water that is held up in tanks, or which infiltrates the ground, takes months or years to reach the ocean...and can be used during the dry months.
- Adequate availability of water, more even distribution (in space and time) and its quality depends on good management practices throughout the watershed.

Natural Ecosystems Are Essential

- Natural ecosystems (consisting of plants) are part of watersheds and are essential in maintaining their health.
- They improve the quality and quantity of water and available to humans.

Let’s see how...

How Do Plants Protect the Soil and Water?

- Raindrops impact the soil at their terminal velocity (At sea level, 7.2-32 km/h. [ref]
- Create small craters,[6] & eject soil particles upto 0.6 m vertically and 1.5 m horizontally.
- If soil is vegetated or covered with ground litter, the impact is intercepted.
  - Water trickles gently to the soil, preventing soil damage.

1. Image 1 Credit: Hans Braxmeier, Pixabay. Source: http://pixabay.com/en/downpour-rainstorm-rain-shiver-wet-8823/
2. Image 2 Credit: US Department of Agriculture - WEPP 95 CD-ROM, Source: http://en.wikipedia.org/wiki/Erosion#mediaviewer/File:Water_and_soil_splashed_by_the_impact_of_a_single_raindrop.jpg

Vegetated Soils Reduce Runoff

- Vegetation slows runoff velocity: limits sheet erosion.
- Roots hold the soil; prevent gully formation.
- Vegetated soil (shade and ground litter) provides shade and moisture for soil creatures that burrow and turn the soil.
- The plant root mass and ground litter adds organic matter to soil, which provides nutrients and soil carbon (humus) to the soil; improves fertility.
- Some plants fix nitrogen and improve fertility.

How Do Plants Protect the Soil and Water?

- Soil rich in organic carbon → absorbs water like a sponge→ greater moisture retained → improved productivity of the the land.
- Such soil has a crumbly structure (high porosity). Also, it has burrows of soil organisms like earthworms.
- This leads to high rates of ground infiltration of rainwater→ high aquifer recharge; reduced runoff.
- Reduced runoff and reduced silt load.

Plants--Essential for Water Management

Rain falling on→ Causes:	Barren Land	Vegetated Land
Direct impact of raindrops on soil	Yes	No
Loss of soil structure, soil erosion	Yes	No
Ground infiltration, aquifer recharge, slow discharge to streams and rivers throughout the year	Low	High
Surface runoff and downstream flooding, silting of downstream dams.	High	Low
Potential downstream usability of water by humans throughout the year (via wells, borewells and rivers)	Low	High

Watershed as a Whole

- As water flows downstream after rainfall we must:
  - Slow it down to prevent erosion.
  - Store it in tanks, ponds and lakes wherever possible.
  - Encourage ground infiltration (aquifer recharge).
  - Prevent pollution (urban or agricultural pollution)
  - Prevent over-extraction. Plan water use based on availability.
  - Minimize leakages and evaporative losses
  - Consume consciously.

Watershed Management Practices

- Protection of vegetation in the catchment (control of deforestation, overgrazing and fire).
- Terracing, contour trenches, planted bunds, swales.
- Tanks, Farm ponds, percolation tanks.
- Check-dams, small and medium dams.
- Prevention of overuse and wastage of ground and surface water.
- Planting of water conserving and locally & seasonally adapted crops.
- Prevention of water pollution.

Watch Video: [Watershed Management](https://www.youtube.com/watch?v=Nk58syLzMF8) (2.10 min)

Credit: WOTR India. Source: https://www.youtube.com/watch?v=Nk58syLzMF8

Flood Management in Watersheds

- Reducing the scale of floods through better catchment management, controlling runoff, and protection of wetlands.
- Multiple small dams (with fish ladders etc), bunds, percolation tanks throughout catchment
- Isolation of flood threat by flood embankments, flood proofing and limiting floodplain development.
- Increasing people's coping capacity with emergency planning, forecasting, warnings, evacuation, compensation and insurance.

Energy in Watersheds

- Large hydroelectric projects generate large amounts of power but have high socio-environmental costs.
- Alternative watershed management programs can also generate power by:
  - Distributed micro-hydro (<100KW) & mini-hydro (<10MW) projects.
  - Deploying other renewable energy sources such as wind, solar and biogas throughout the watershed...

Need for Community Involvement

- Community-driven, awareness, education, gender-equality, justice, local livelihood generation.

Watch Videos: Hiware Bazar: The town of 52 Millionares (9 min).

The ideal village in india -- hiware bazaar (8.43min)

Credit: Leah Temper, CEECEC. Source: https://www.youtube.com/watch?v=0GrUvNHYO_k

Dying wisdom

Ancient methods intercepted the flow of water without ecological disturbance.

- **Hill and mountain regions:**
  - Diversion channels (*guhls* and *kuhls* of western Himalaya).
- **Arid and semi-arid regions:**
  - Tanks (the *eri* system of Tamil Nadu).
  - Checkdams (*johads* of Rajasthan).
- **Plains and floodplains:**
  - Inundation channels (West Bengal).
- **Coastal area**
  - Control saline water intrusion(*khazana* lands of Goa).

Low cost, community controlled, adapted to local ecology and offered protection from droughts and floods.

Activity: Identify Your Watershed

- Which watershed do you belong?
- Classify: Well-vegetated, partly, degraded, urban
- What are the major issues?
- Intervening for Solutions:
  - Identify governmental agencies
  - Identify NGOs
  - Form or join citizens groups
  - Industry associations
  - Legal instruments

National Rural Employment Guarantee Act

Watershed Works Manual 2006

Outline

- Water Cycle
- India's Water Crisis: Depleting resources, pollution, dams agitations, scarcity.
- Sustainable Solutions
  - Supply Side
    - Rainwater Harvesting
    - Watershed Management
  - Demand Side
    - Conservation in Agriculture
    - Conservation in Industry
    - Conservation in Domestic Use

Once we have enough water available for our use, how can we maximize its benefit?

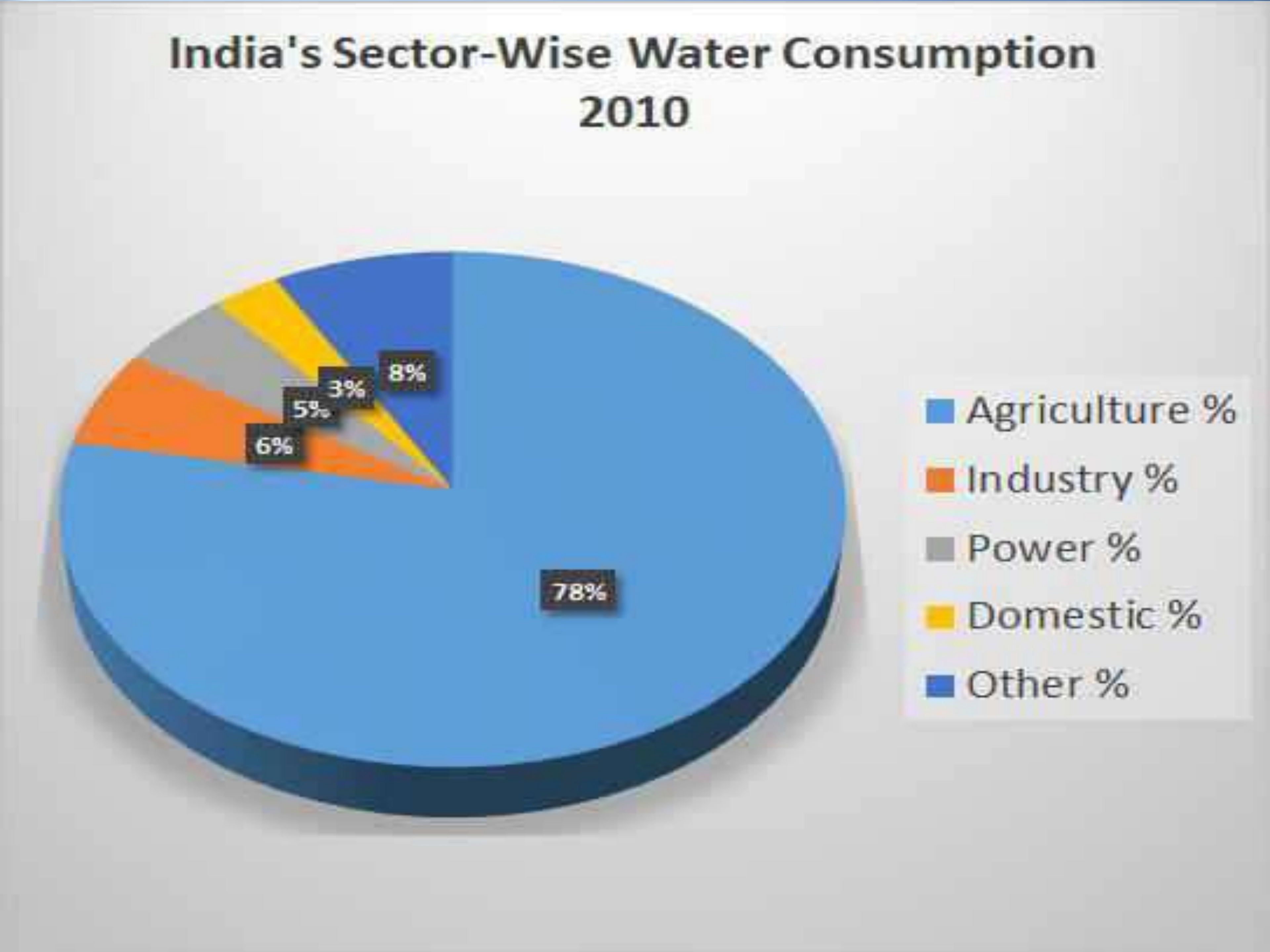
Or how do we use the minimum water to get the desired benefit?

India's Water Consuming Sectors

Sector	2010	2050
Agriculture %	78	68
Industry %	6	7
Power Development %	5	6
Domestic %	3	9.5
Other % (evaporation, environment, navigation)	8	9.5
TOTAL (BCM*)	710	1180

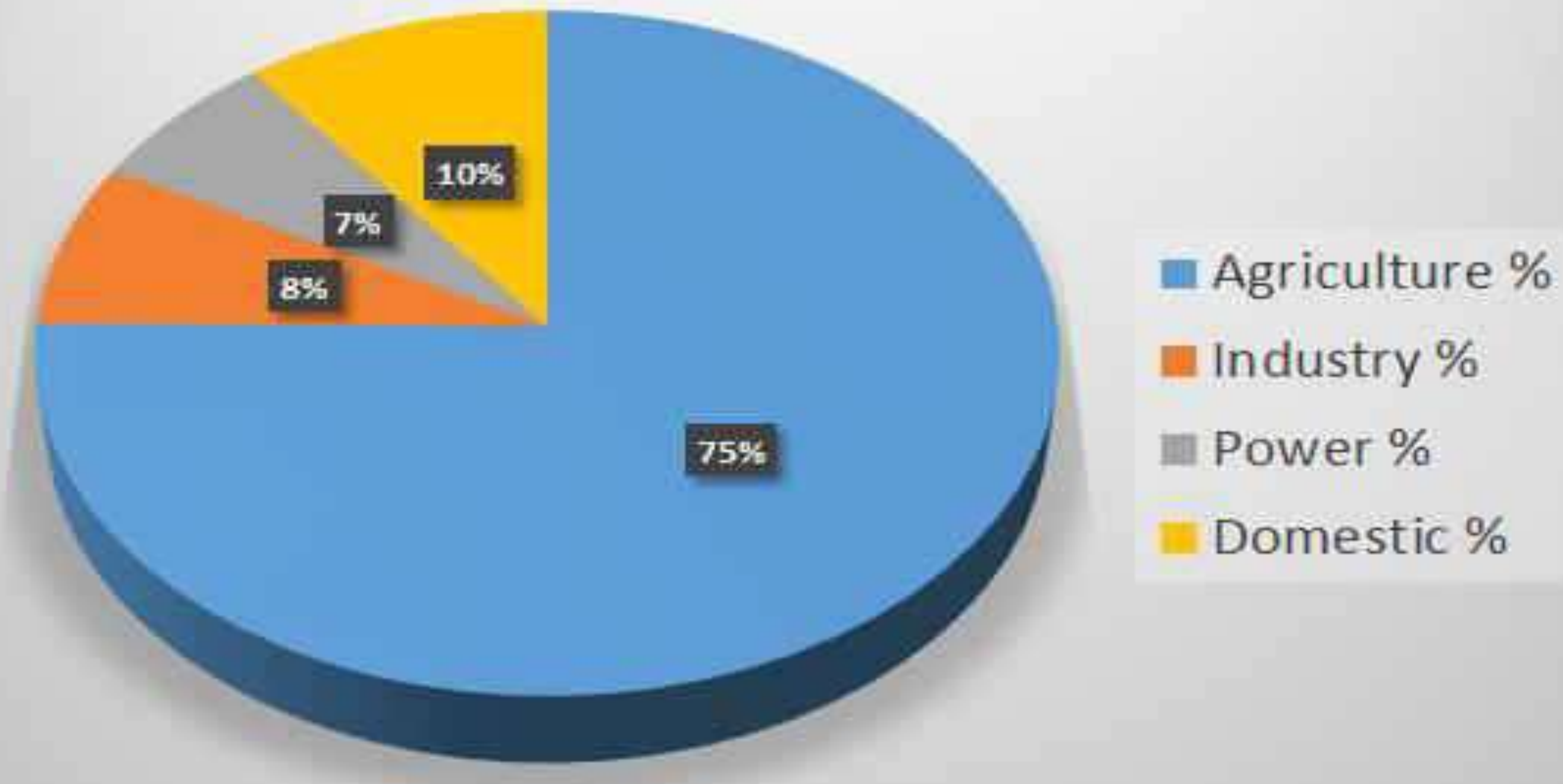
* Billion cubic meter

The National Commission for Integrated Water Resources Development (NCIWRD)



India's Sector-Wise Water Consumption
2010
8%
3%
5%
6%
78%
Agriculture %
Industry %
Power %
Domestic %
Other %

India's Sector-Wise Water Consumption 2050



Water in Agriculture (78% of total)

Water, agriculture, food and waste are inseparable.

- 78% water goes for agriculture.
- >50% food comes from irrigated land (35% of arable land).
- Land Degradation (loss of soil carbon and moisture) affects 105 mi. ha (32.07%)-- A Rs. 28,500cr./yr loss of productivity.
- **Low input organic polycultures (agro-ecosystems) can revolutionize agriculture and water use.**
  - Yields of rainfed arable land (65% of total arable) can be improved drastically (15-150%)
  - Can drastically reduce the water use of irrigated lands while providing the same yield.
  - Inputs of carbonaceous waste to soil can drastically improve productivity & reduce water use.

Food, Water, Land

Watch:

- Change the Way You Think About Food (2.16min). --WWF.
- 300 Year Old Food Forest in Vietnam (6 min)

Low Input Organic Polycultures

Need to develop highly productive low input polycultures/ intercropping/ agro-ecosystems with the following features:

- Max. food calories/liter water[ref].
- High diversity including alternative crops such as minor millets and vegetables, tree crops etc.
- Crops adapted to local conditions: temperature, drought, salinity, pest and disease resilience etc. so that minimum inputs are required.
- Strategies such as mulching, biochar amendment to reduce soil water evaporation, retain soil moisture and nutrients.
- Use conservation irrigation practices such as drip irrigation.
- Using greywater / reclaimed water for irrigation.
- Conservation-favoring water tariffs, regulation, subsidies.

Industrial Water Use (6% of total)

- **Industry runs to provide us with the products we buy. All of them need water and energy to make, distribute, use and discard.**
- All products contain embodied water:
  - Potato (100g) 25L
  - Slice of bread (30g) 40L
  - Cup of coffee (125ml) 140L
  - Bag of potato crisps (200g) 185L
  - Glass of milk (200ml) 200L
  - Hamburger (150g) 2400L
  - Cotton T-shirt (medium, 500g) 4100L
  - Pair of shoes (bovine leather) 8000L

Your shopping drains the nation of water and energy!

Reducing consumerism reduces the crisis in water and energy.

Outline

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Industrial Water Use

- **Specialized treatment is needed for industrial effluent.**
- **Green chemistry and green production processes can reduce the environmental impacts significantly.**
- **Industries must gradually evolve towards recycling water 100%; closed loop production.**
  - This can raise production costs & encourage conscientious consumption.
- **Industrial symbiosis networks can allow exchange of material and energy streams between processes within the same industry and other industries and industry to non-food agriculture.**
- **Use low-energy water treatment and recycling where water is free of persistent and highly toxic pollutants.**
  - e.g. Planted filters, constructed wetlands, soil biotechnology (IIT-B), DEWATS etc.

Case Studies of Industries having closed the water loop. [ref]

Outline

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    - Rainwater Harvesting
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    - Conservation in Domestic Use

Domestic Water Use in India (3-5% of total)

- Local scarcities are common: high pop. density relative to water availability.
- Sewage contamination is a major contributor to water pollution.
- 70% surface water sources polluted.
  - ***68% wastewater is discharged into river, lakes and ground, untreated.***
- Conventional treatment costs are high; but alternatives exist.
- Sewage contains Rs 1,091 mi. of agro-fertilization value that is lost annually. **Can we recover this value?**

Greening Domestic Water Use

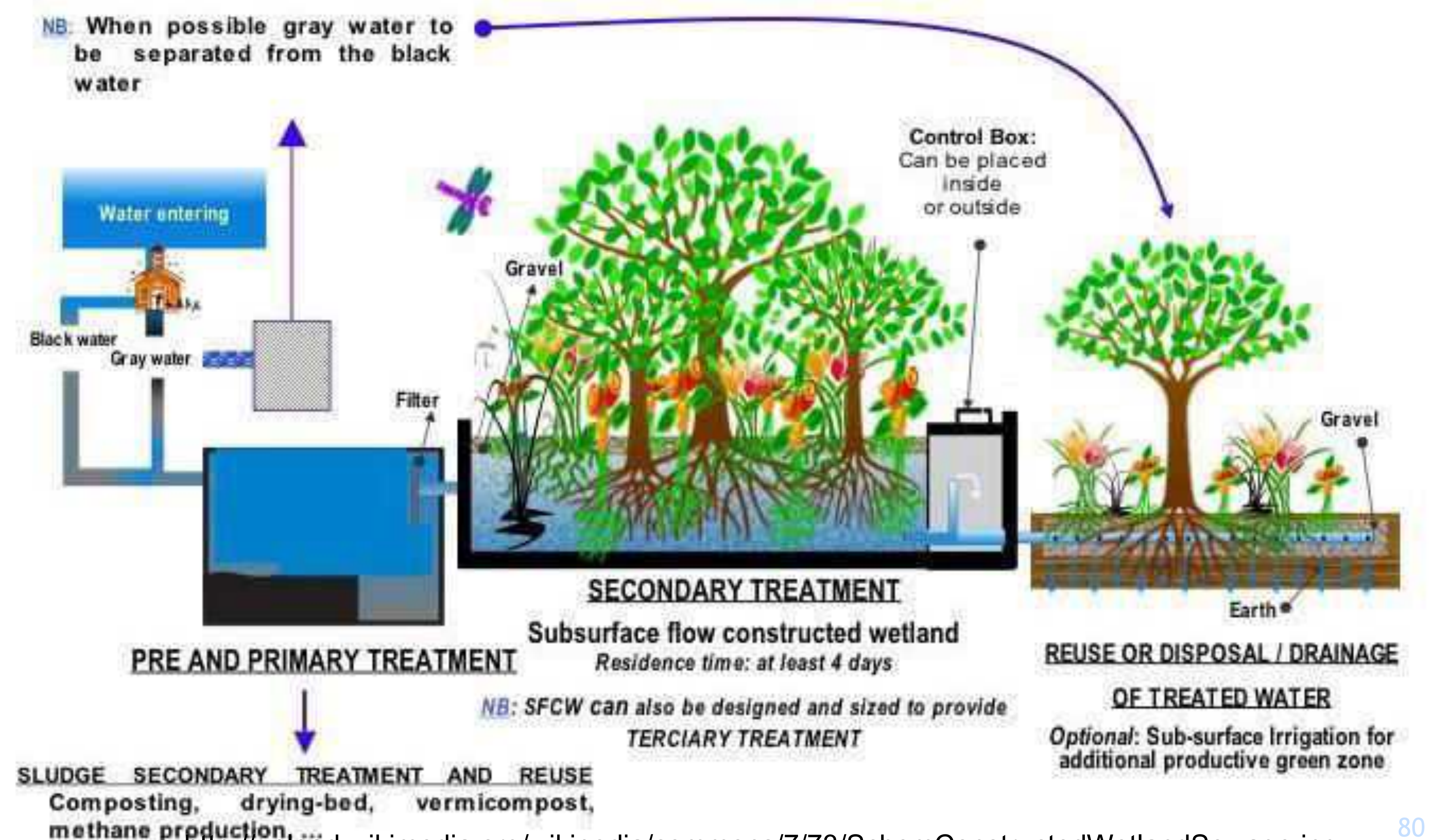
- **Integrated water, energy, waste disposal and food production systems at household/community scale.**
- **Eliminate persistent chemicals from the water use cycle to facilitate recycling and reuse.**
- **Separation of greywater from blackwater (approx. 50-50 proportion)**
  - facilitates water reuse
  - reduces energy consumption and cost of treatment.
- **Composting toilets can**
  - Reduce the household water use by nearly 50% (flush-free)
  - Save a lot of energy.
  - Yield compost with high nutrient value for agriculture or gardening.

Alternative Wastewater Treatment Methods

- **Alternative methods of wastewater treatment can save a lot of energy (& money):**
  - Conventional: 1800-8000 KWh/MG
  - Alternative method (Video: Soil biotech method, IITB 7.28 min): 0.01 KWh/MG [ref1 ref2 ref3]
  - **Planted filters, constructed wetlands, DEWATS etc.**
  - Provide substantial benefits (like compost, agricultural produce, biogas etc.)
  - Can have longer treatment times and greater land requirements.

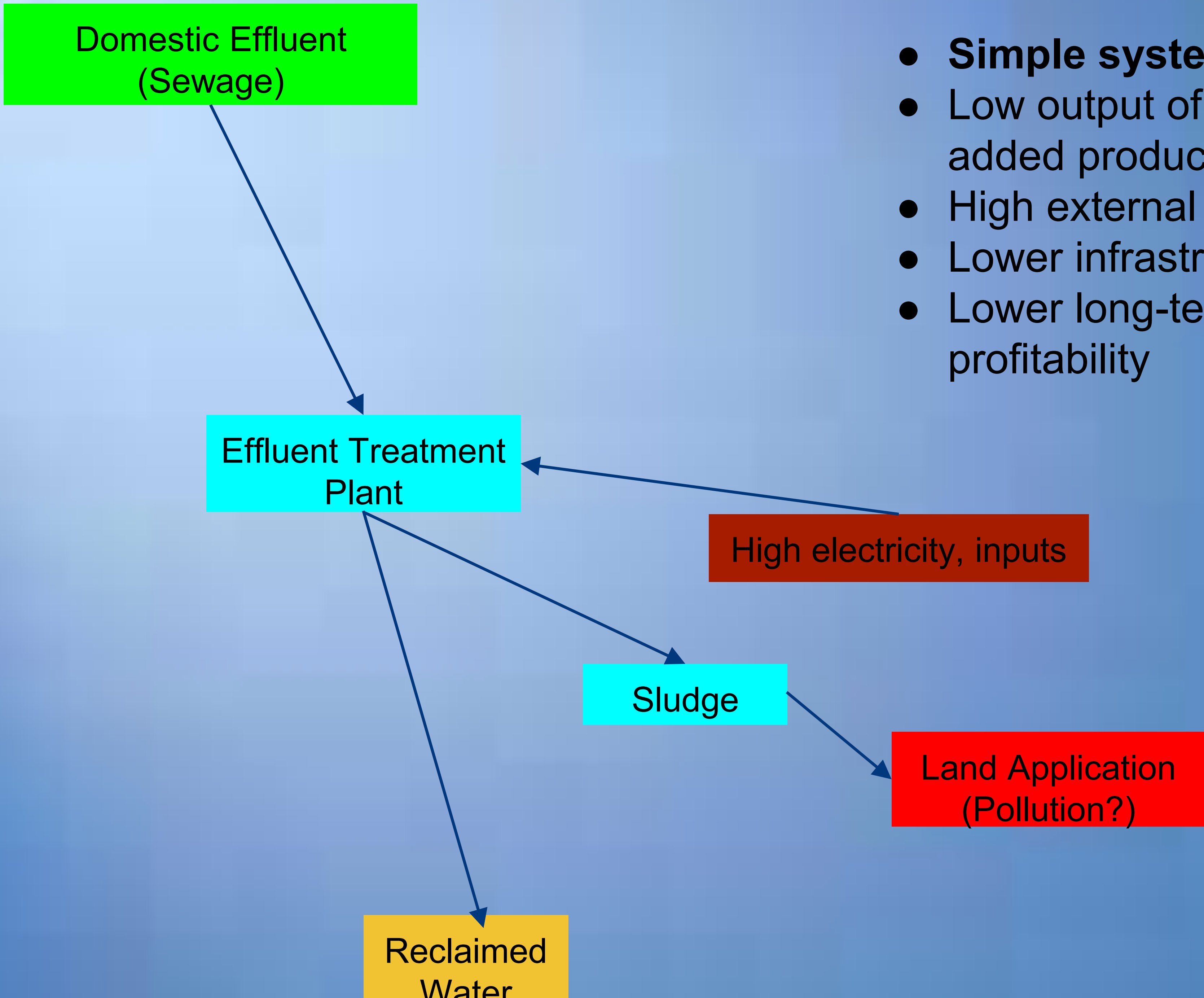
Alternative Wastewater Treatment

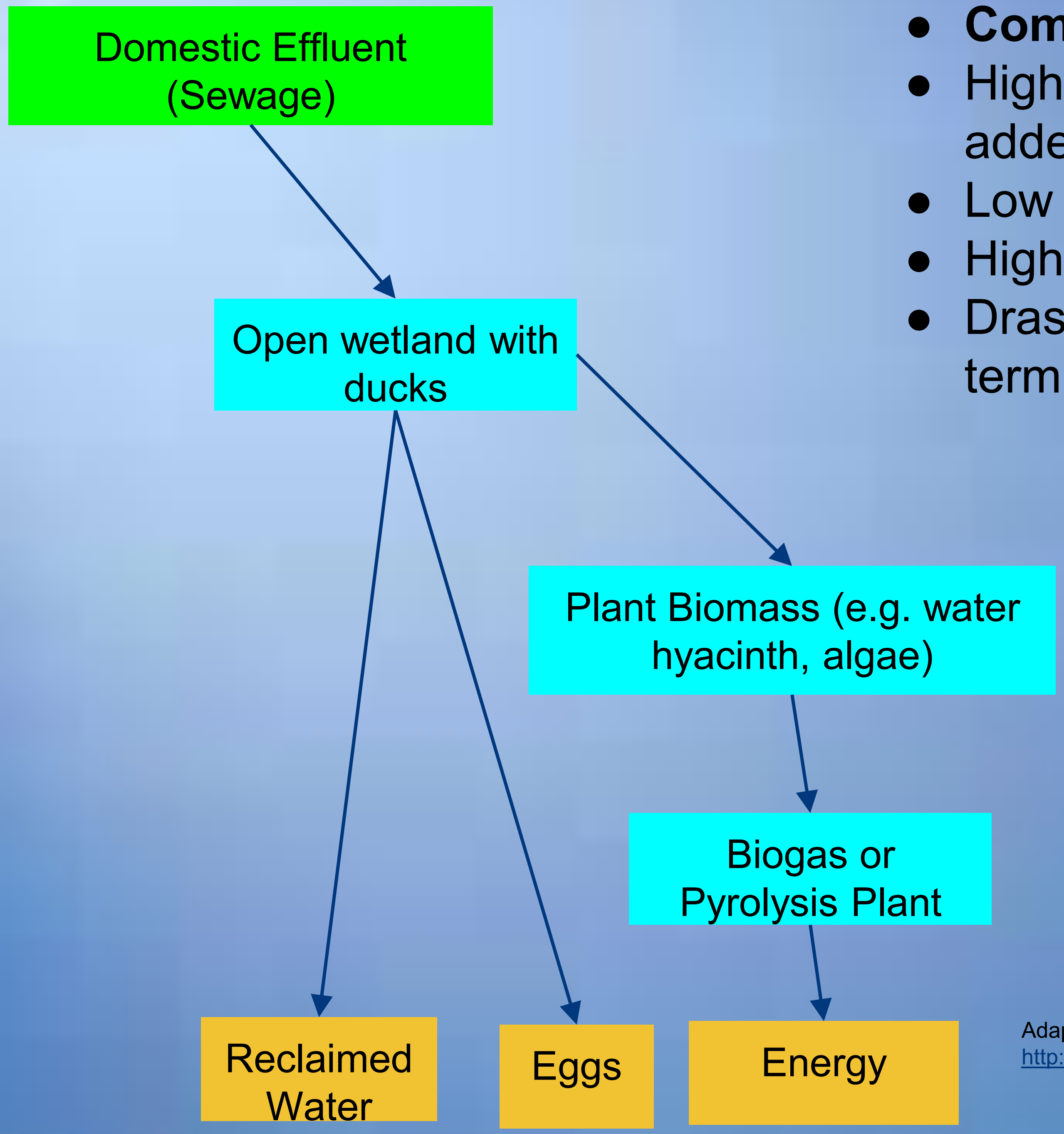
Subsurface flow constructed wetlands (SFCW)



http://upload.wikimedia.org/wikipedia/commons/7/73/SchemConstructedWetlandSewage.jpg

- **Simple system**
- Low output of value-added products
- High external inputs
- Lower infrastructure
- Lower long-term profitability





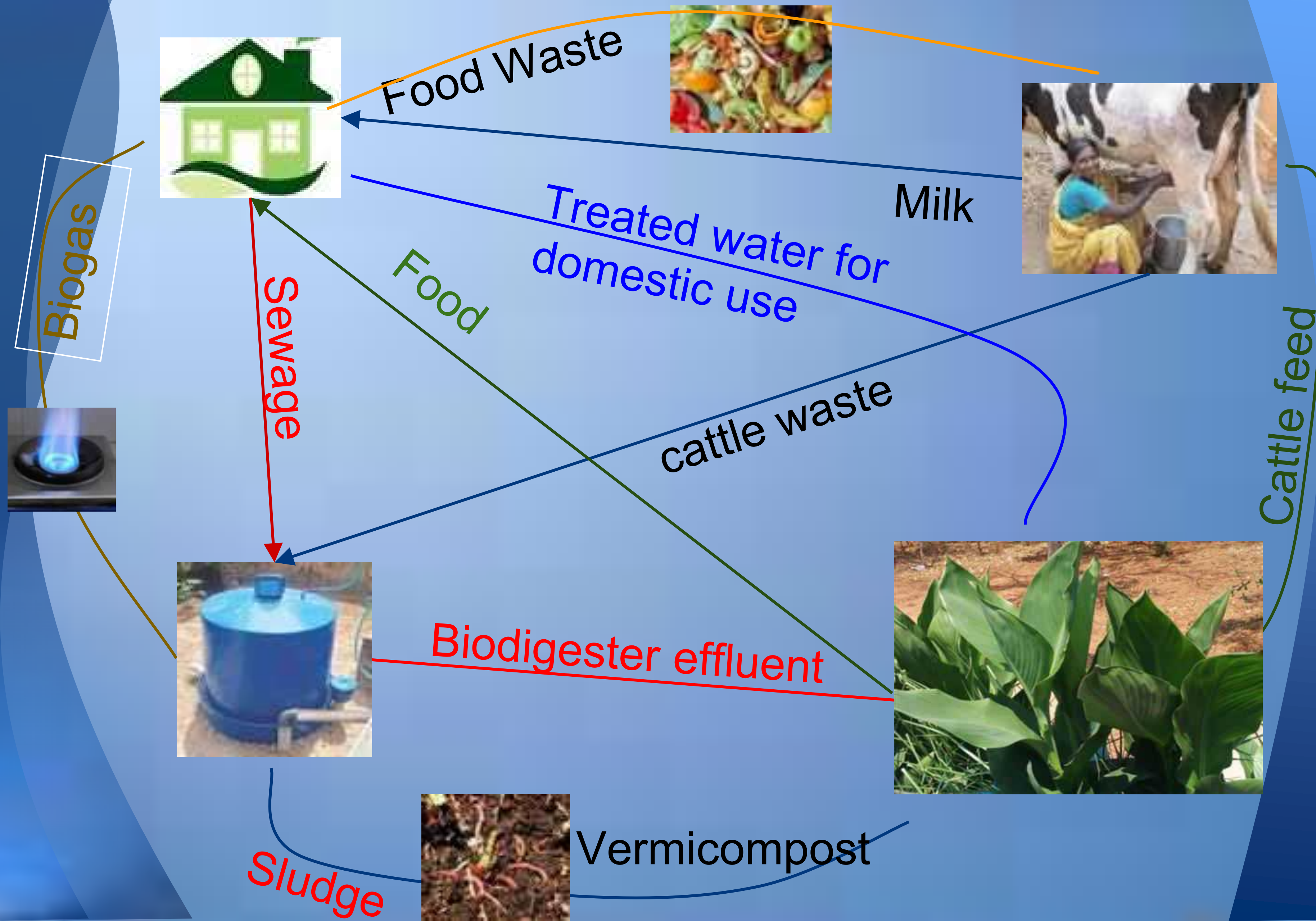
- **Complex system**
- High output of value-added products
- Low external inputs
- Higher infrastructure
- Drastically higher long-term profitability

Adapted from:
http://www.indiangreenservice.com/resources.html

Solution for Multiple Related Problems

- A water-management strategy that:
  - Treats wastewater to domestic use quality (pathogen removal, BOD reduction, turbidity and odor removal).
  - Provides reclaimed water (reduces the need to extract water from environmental sources.)
  - Consumes less energy or...PROVIDES ENERGY!!
  - Is low cost or...GENERATES REVENUE!!
  - Consumes less space or provides multiple uses of the same space.
  - Provides other products such as food or wood (reduces the need for irrigation elsewhere)
  - Reduces problems of urbanization by providing green spaces, recreation.

Schematic of a Multi-Utility System



Potential System Outputs

- Treated water returned for domestic use.
- Vermicompost
- Biogas
- Food (fruits and vegetables)
- Milk
- Wood

Planted Filter

Watch Video: Smart & Ecological Use of Roofs (5.10)
Relevant resources: http://www.sswm.info/

What can I do?

- Minimize personal water use (domestic, gardening, etc)
- Consume only what you need. Shop less and waste nothing!
- Install/build home greywater recycling systems.
- Use the recycled water for a kitchen garden.
- Install water-conserving toilets or composting toilets
- Close / repair leaking taps
- Use natural domestic and personal cleaners and cosmetics. Avoid toxic chemicals in the home and garden.
- Install rainwater harvesting.
- Disseminate information on efficient technologies, organic farming.

Thank You!

Extra Resources

What is Watershed Development? (2.10min)

Drainage System in India | 3D Animated Education Video of Class 9, 10 | ncert history (9min)

Environmental Science videos on Consortium on Educational Communication-UGC.

Chapter 9

Automobile Emissions Controls

Stationary Emissions Control

Cost of Emissions Controls

Thermal Pollution from Energy Generation

Ecological Effects of Thermal Pollution

Cooling Towers

Using Waste Heat

Energy in the News

Thursday Energy Roundtable at SIPA Cancelled:
Not yet rescheduled

Automobile Emissions Controls

Emissions can be controlled in several ways

Change the fuel used by the car

Change the way that the engine burns the fuel

Decrease the use of cars by subsidizing mass transit

Changing the Fuel

Table 8.4 GASOLINE ALTERNATIVES

Fuel	Source	Benefits	Drawbacks
Methanol	Coal, wood, gas	Fewer hydrocarbons and CO_2 High octane	Less energy content
Ethanol	Corn, sugar	Fewer pollutants High octane	Less energy content High fuel cost
Compressed gas	Natural gas	Inexpensive Fewer hydrocarbons and CO_2	Expensive vehicle conversion
Electricity	Fossil, nuclear, solar	No car emissions Power plant emissions easy to control	Limited range Battery cost

What are other names for methanol, ethanol and compressed gas? How are they made? Other drawbacks of these fuels?

The Newest Fuel: Nitrogen

Liquid Nitrogen Fuel

This Car Runs on Air

The vehicle runs on nitrogen, which makes up 78 percent of our atmosphere.

Abe Hertzberg, professor emeritus of aeronautics and astronautics at the University of Washington, and one of his students pose with the LN2000, the nitrogen-powered vehicle they have developed (Universtiy of Washington)

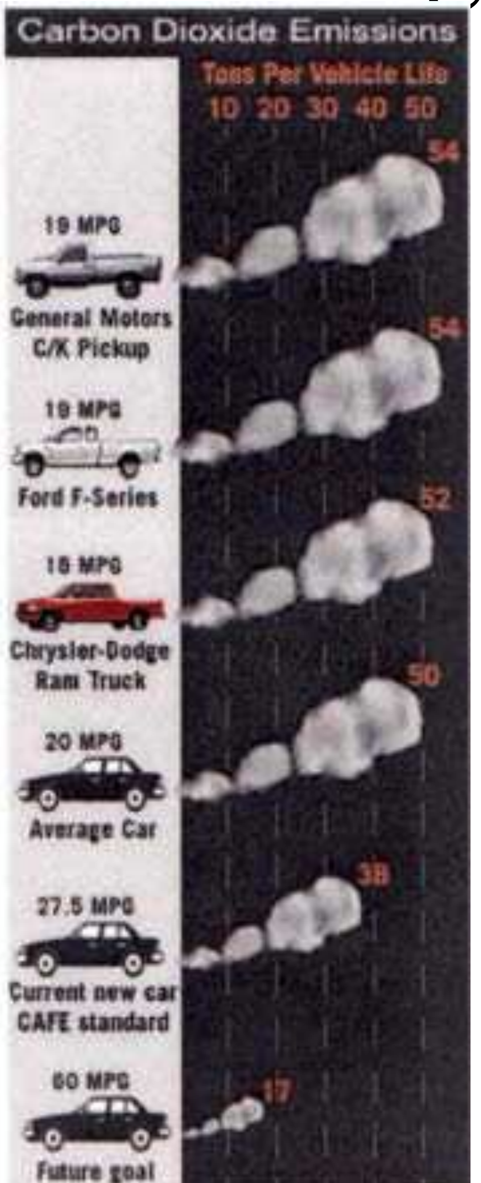
LEE DYE

Newest alternative fuel
(reported this Monday)

Works by using
decompression of
Liquid nitrogen to
Push pistons and run
The car engine.

No pollutants at all, BUT
Technology not mature.

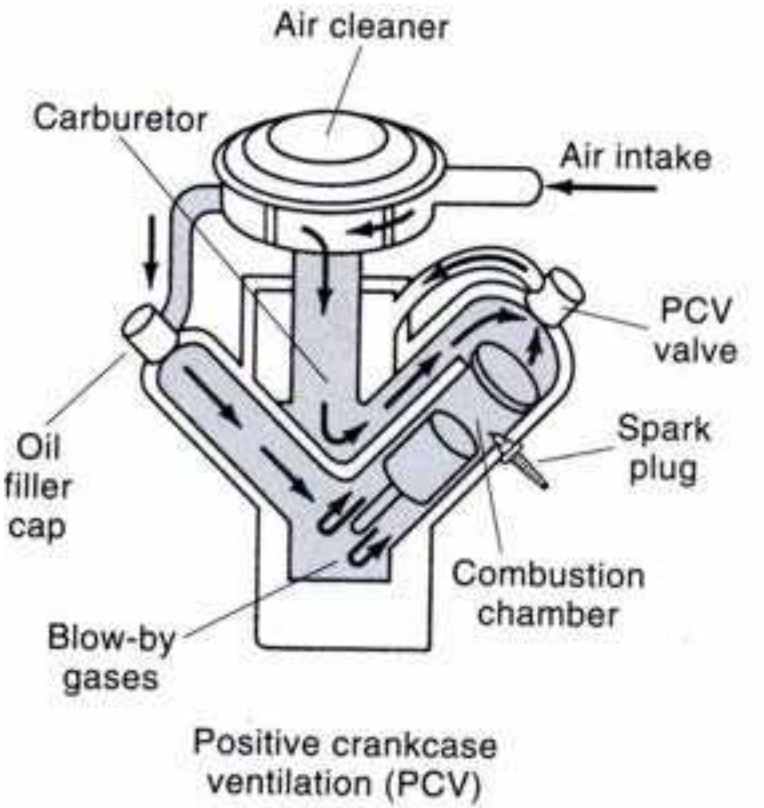
Changing the Burning Process



More efficient cars emit less CO2 per mile traveled.
(In the 1970s, estimated that could run
All cars on ethanol and methanol derived from
Fermented biomass if all cars averaged 60 miles
Per gallon.)
Number is out of date, but at some gas mileage
It is possible to run all cars on renewable sources
Of hydrocarbons.

Amory Lovins: using the best technology:
Could potentially build cars
That get 150 miles per gallon.

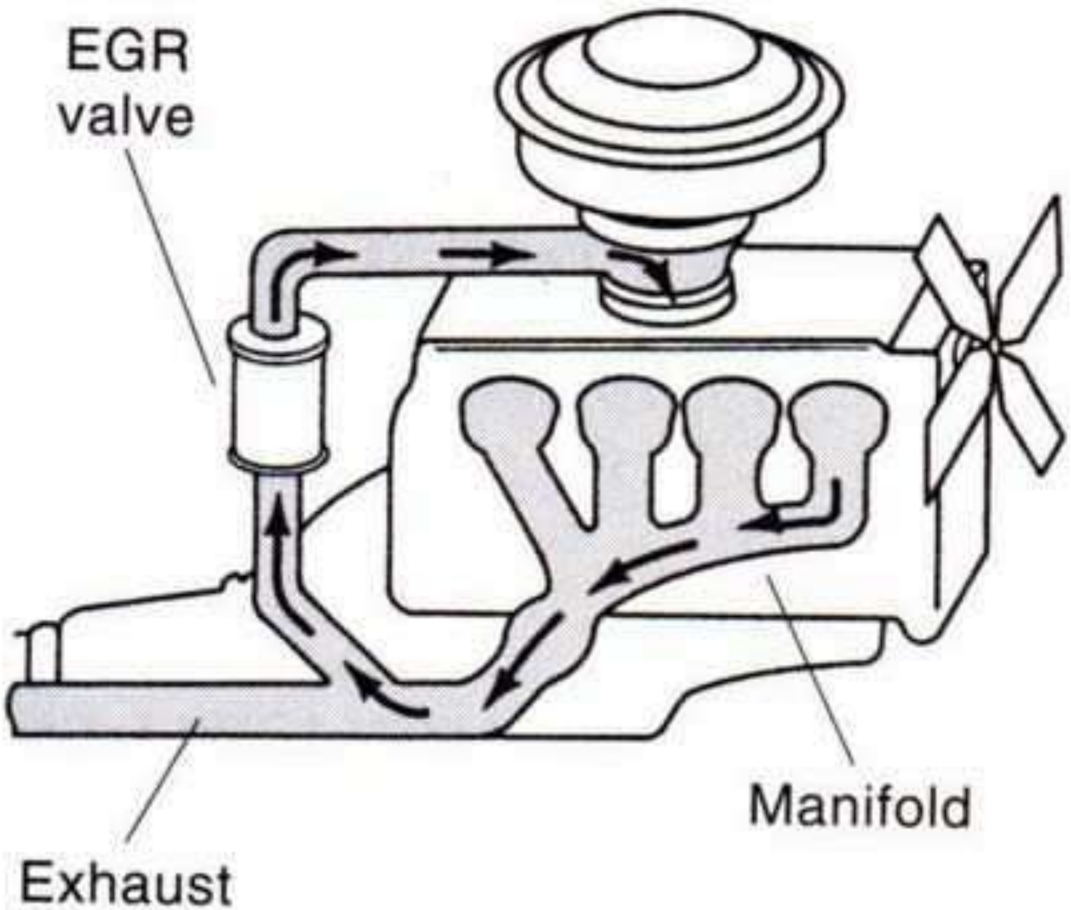
Positive Crankcase Ventilation



At the edges of the combustion
Chamber of the engine
(above the piston tops), there is a
thin layer of gasoline that does
Not burn up. This gasoline
Constitutes an air pollutant
(what is its classification?)

To keep gasoline from returning to
The air, this gasoline is recirculated
Back into the combustion chamber.

Exhaust Gas Recirculation



Exhaust gas recirculation (EGR)

Exhaust gases are
Removed from the
Crankcase and then
Recirculated back into
The carburetor.

Other Pollution Controls

Minimize CO and hydrocarbons by improving burning
Of the fuel.
To improve burning: use leaner fuels and increase
Temperatures in the combustion chamber.

Leaner fuels: means mixture of air plus fuel has more
Air and less fuel.

But leaner fuels increase Nox formation because
Burning is at higher temperatures and more oxygen is
Available to form Nox.

Catalytic converters: help to get around these problems.
They require unleaded gasoline.

Automobile Emissions Standards

Table 8.6 AUTOMOBILE EMISSION STANDARDS (grams per mile)

Pollutant	1975	1990	1998
Hydrocarbons	3.4	0.41	0.25
NO_x	3.1	1.0	0.4
CO	34	3.4	3.4

Standards met by using catalytic converters, engine Redesign and additives (MBTE, other oxidants).

Mass Transit

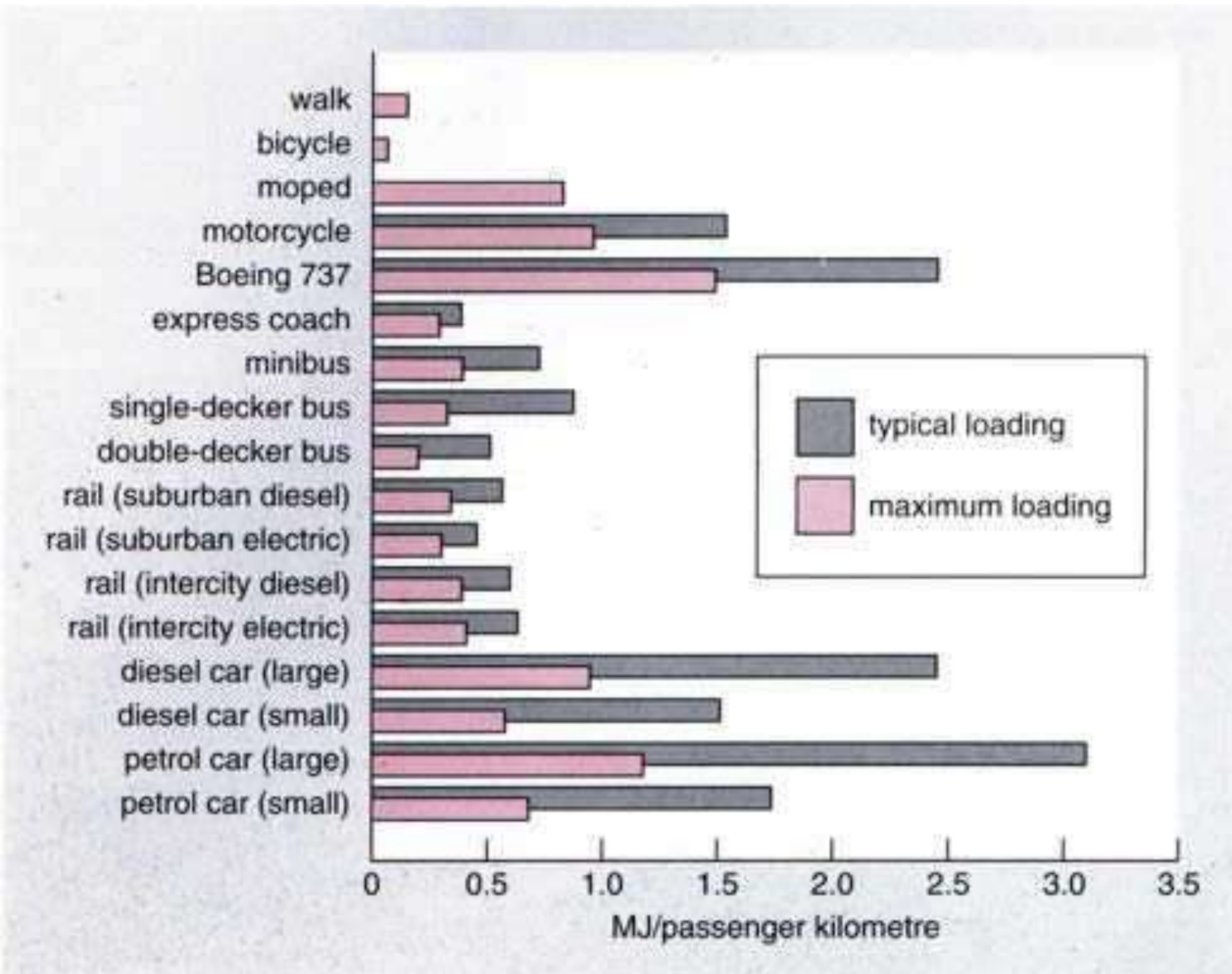
Shin Kan Sen (Bullet Train), TGV (Train Grande Vitesse)
Both are MAGLEV (magnetic levitation) trains
Travel at up to 300 km/hr (180 mph)

Shin Kan Sen: Trains leave every 3 hours: Tokyo-Kyoto
TGV-not so often

Buses like subways(pay fare before getting on in enclosed area)
Most efficient form of public transport
Exist in Brazil

Biggest problem: Load factor
If not used enough, mass transit is LESS energy efficient than cars
90% of public funds in US used to build highways

True Energy Use by Transportation



In theory, a train
Is 15 times more
Energy efficient than
A car.

Considering load
Factors, what is
The more typical
Ratio of efficiency?

What is the most
Energy efficient
Transportation?

Reducing Pollution from Stationary Sources

How pollution is reduced;

1) Change the fuel

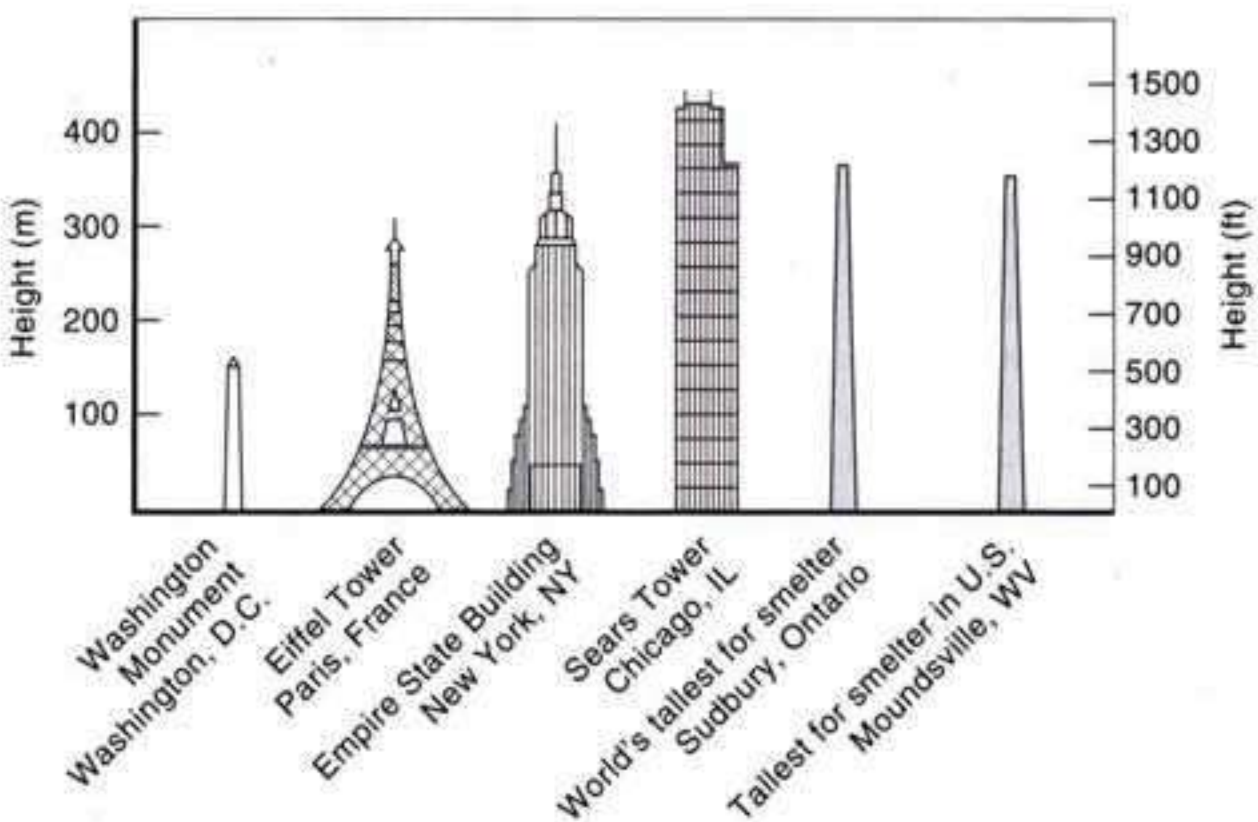
2) Change how the fuels burns

3) Remove pollutants after burning

Other methods don’t really reduce overall pollution, they Shift it in time or in space, what are these methods?

Shifting the Pollution in Space

Sudbury Ontario: giant astrobleme-Worlds biggest Ni mine
One of two oldest meteorite impact structures: 1.8 Ga (1800 Ma)
(Canadian Nickels)



Ni is a heavy metal; large quantities Are poisonous to people and plants.

What did building a Taller smoke stack at Sudbury do to the landscape?

(Dumping the slag)

Shifting the Pollution in Time

Why does shifting the time at which emissions are made
Affect the resulting air quality? (Ozone for example).

Other strategies not so nice. (At U.S. Mexican border).
El Paso area?

Removing the Pollution

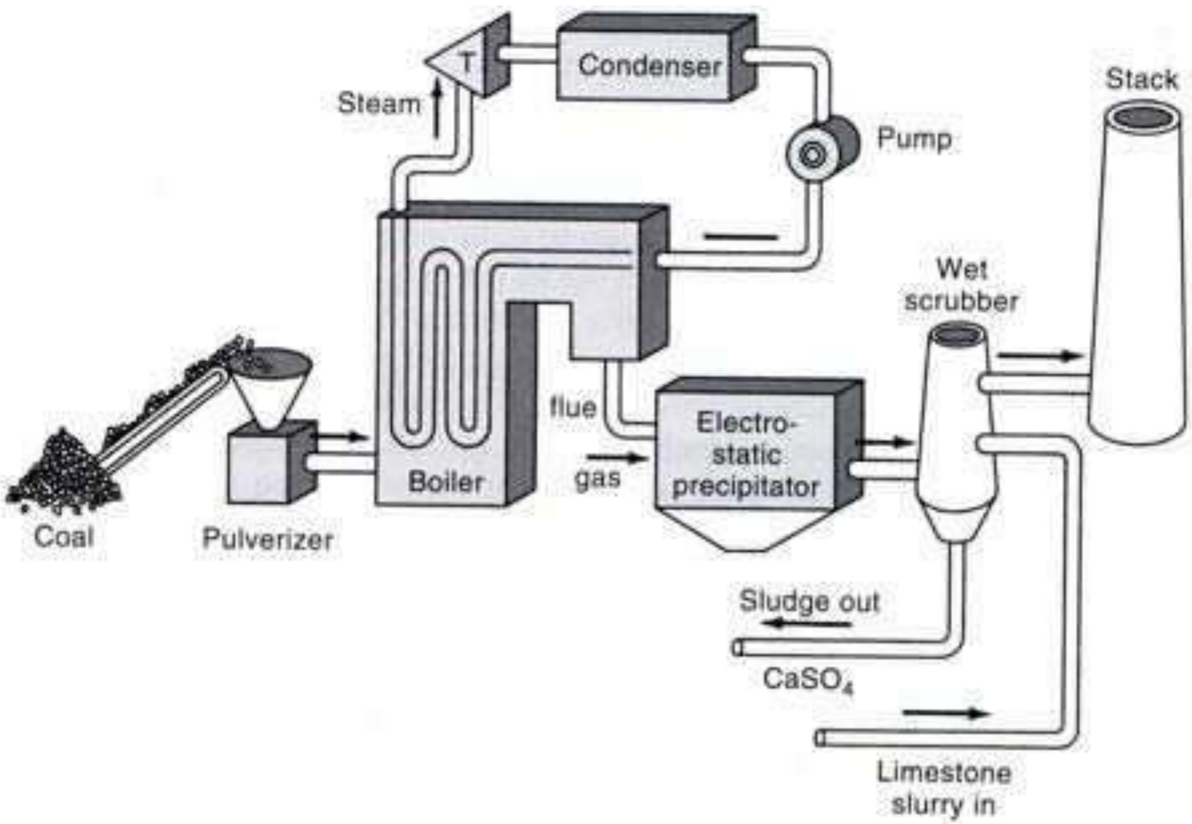
There's Something About Mary, Walton That Is

Looking around most cities today, you will probably see the same thing that disturbed Mary Walton after the Civil War: pollution. The Industrial Revolution that had swept the nation had little regard for the waste that it produced.

Mary Walton, an indepedent inventor was not one to stand idly by choking on the smog that the factories produced. While it did not solve the problem of pollution, she did patent a device in 1879 that minimized the smoke that was pouring into the nation's air. It deflected the emissions into water tanks where they were later flushed into the cities sewage system.

Mary Walton invented an early pollution control device
For factories.

Power Plant Pollution Control

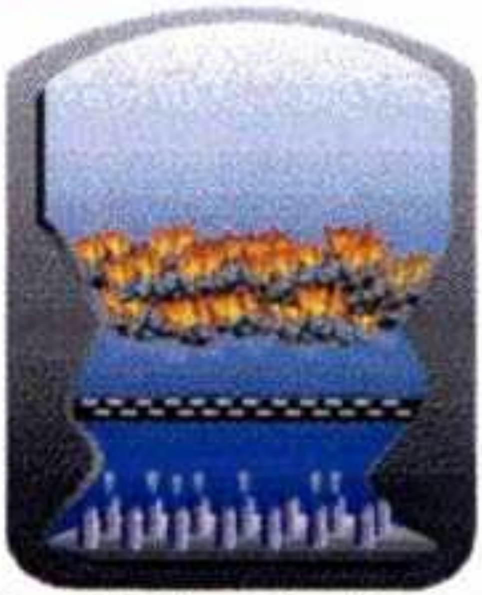


What is being Removed by The electrostatic Precipitator?

By the wet Scrubber?

Fluidized Bed Combustion

A Fluidized Bed Boiler



In a fluidized bed boiler, upward blowing jets of air suspend burning coal, allowing it to mix with limestone that absorbs sulfur pollutants.

Key Reaction:

CaO (lime) + $1/2O_2$ +SO_2
= $CaSO_4$ (calcium sulfate)

Limestone = $CaCO_3$

What else besides calcium sulfate
Is emitted by Fluidized Bed
Combustion (FBC)?

FBC reduces NOx by lowering
Temperature of burning

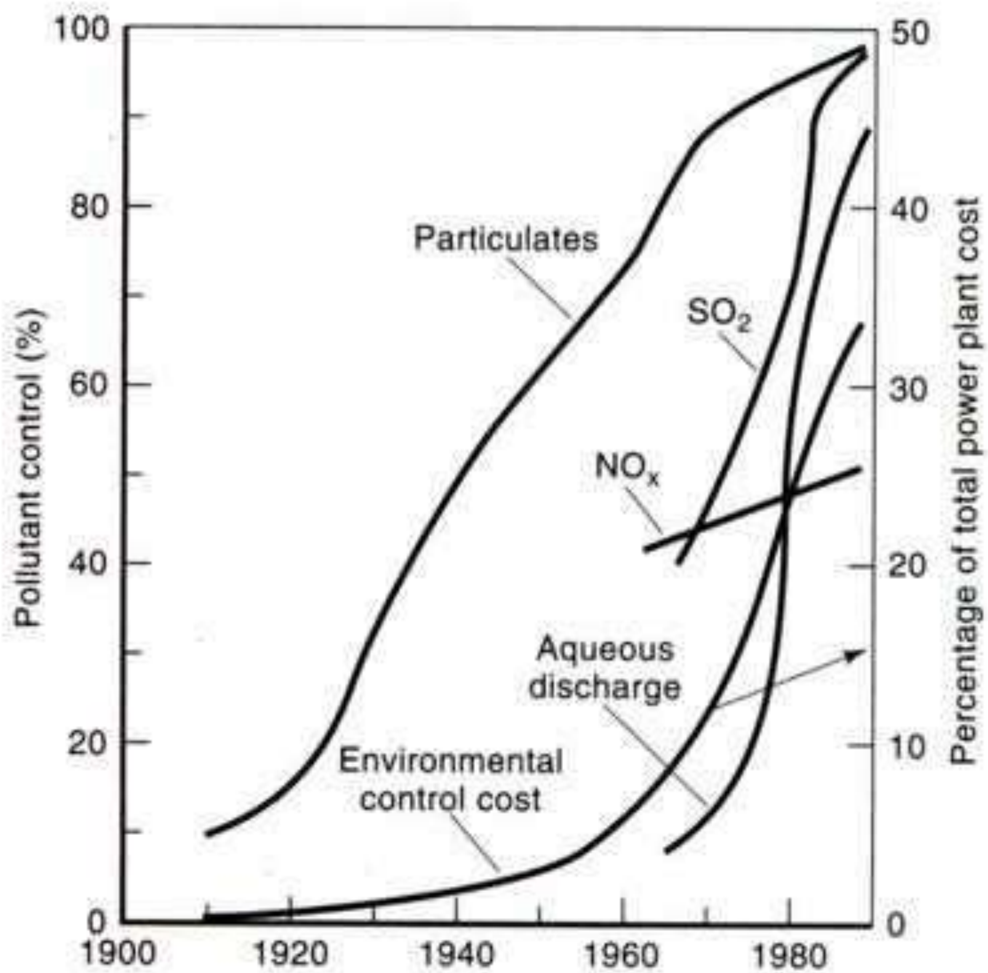
Cleaning the Coal by Crushing and Settling

Although coal is primarily a mixture of carbon (black) and hydrogen (red) atoms, sulfur atoms (yellow) are also trapped in coal, primarily in two forms. In one form, the sulfur is a separate particle often linked with iron (green) with no connection to the carbon atoms, as in the center of the drawing. In the second form, sulfur is chemically bound to the carbon atoms, such as in the upper left.

FeS_2 or pyrite (fools gold):
Very dense.
Can separate from coal using
Settling techniques. Why?

This cleans the coal of part
Of its sulfur.
Remaining sulfur: chemically
Bonded with the coal.

Cost of Pollution Controls



Cost of pollution controls
Left: normalized to 100%
Cost for all pollution
Controls
Right: as a percentage of
Total power plant cost
(only one line is relevant)
Actual cost: typically
About 1/3 of plant cost

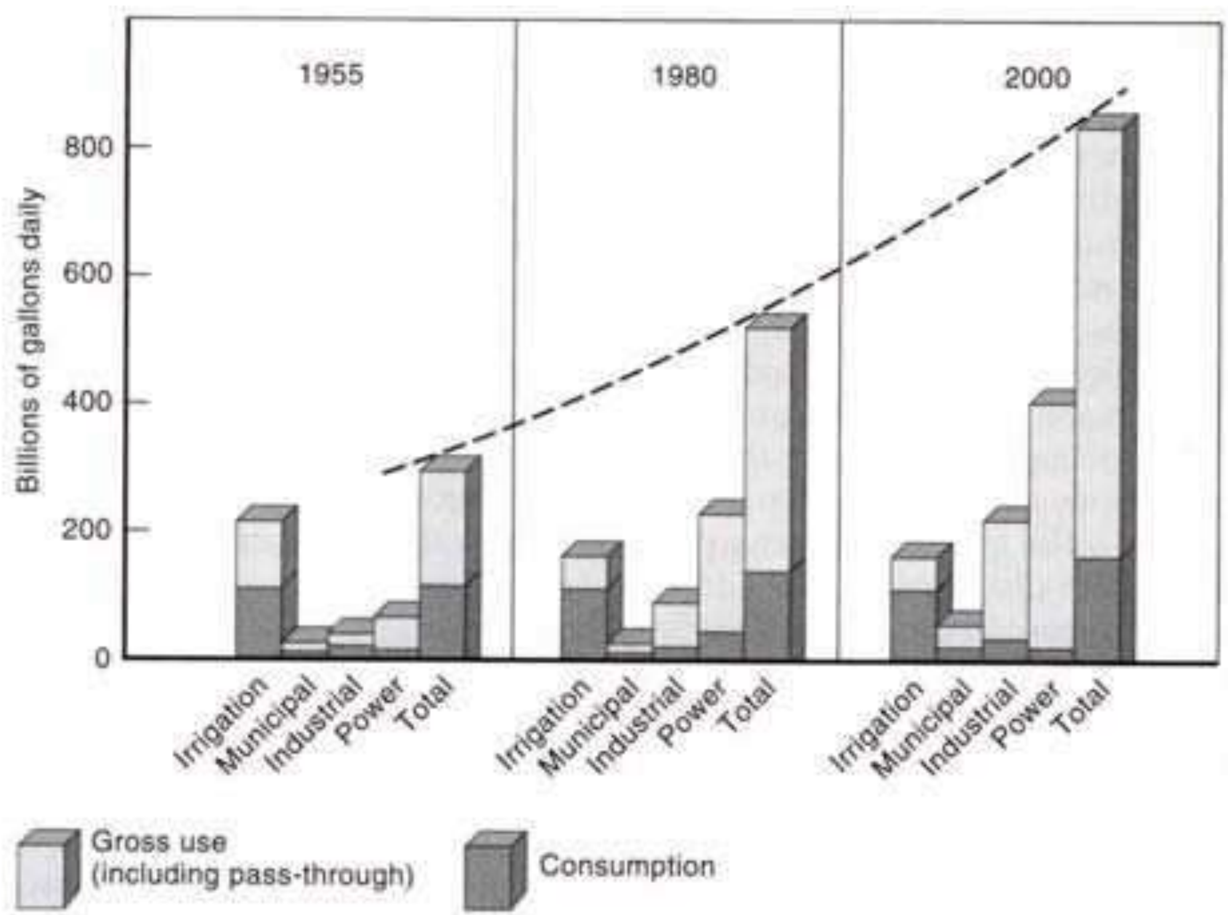
Physics of Waste Heat

Q = m* c* deltaT

Q is heat added, m is mass, c is specific heat
Delta T is the temperature change

What is waste heat?
Why do you get always get waste heat when
You generate power using a heat engine?

Waste Heat and Water Use



Which users are Increasing their water consumption the most?

1855 to 1980?
1980 to 2000?

(Graph is for the United States)

Why?

Waste Heat from Power Plants

Table 9.5 HEAT CHARACTERISTICS OF TYPICAL STEAM ELECTRIC PLANTS (VALUES IN Btu PER kWh)

Plant Type	Thermal Efficiency (%)	Required Heat Input	Total Waste Heat	Lost to Boiler Stack*	Heat Discharged to the Condenser	Cooling Water Requirement (ft^3/s/MW of capacity†)
Fossil fuel	33	10,500	7100	1600	5500	1.6
Fossil fuel (recent)	40	8600	5200	1300	3900	1.15
Light water reactor	33	10,500	7100	500	6600	1.9

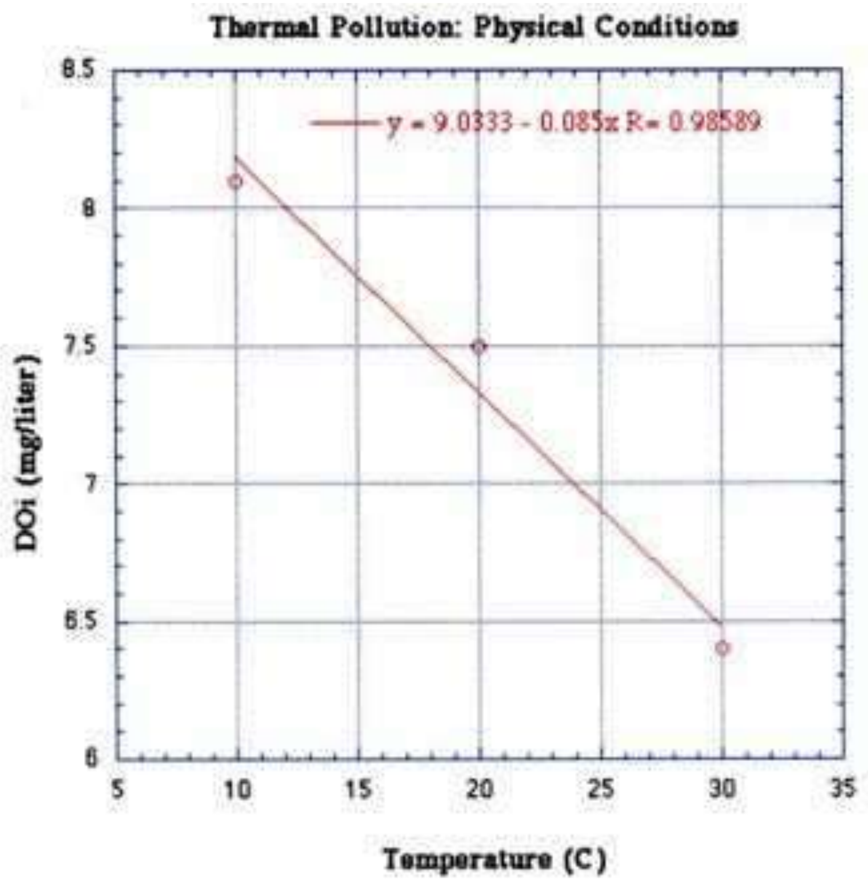
*Approximately 10 to 15% × required input for fossil fuel; approximately 3 to 5% × required input for nuclear.

†Based on an inlet temperature in the range of 70°F to 80°F and a temperature rise across the condenser of 15°F (8°C).

Source: R. Rimberg, "Utilization of Waste Heat from Power Plants," William Andrews Pub. LLC, 1974.

Which portion of the waste heat goes to heat up water
In a water-cooled plant? Which plant type generates
The most waste heat per unit of power output?

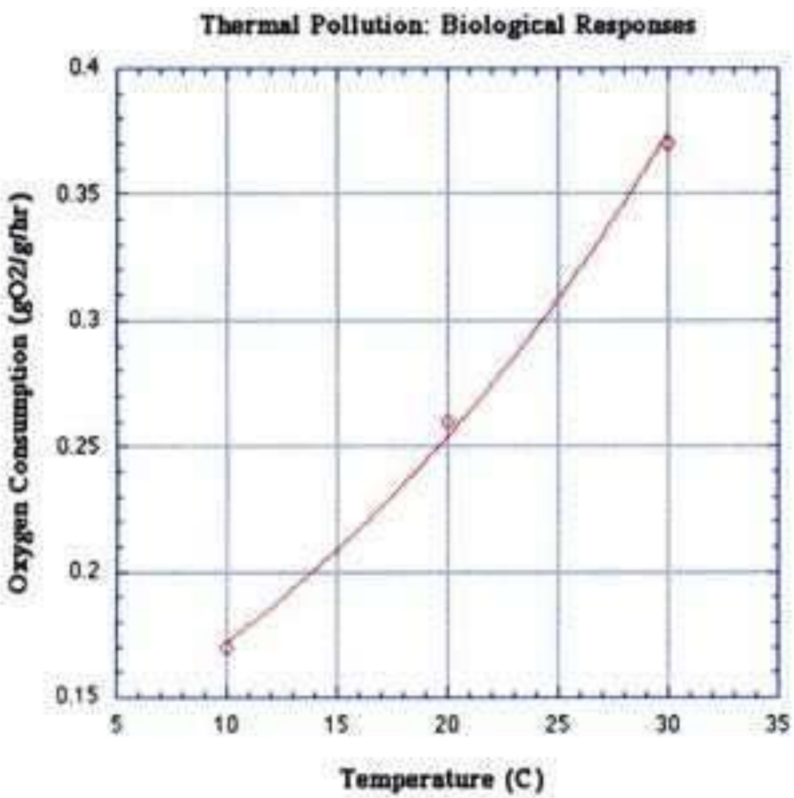
Dissolved Oxygen in Water vs T



How does the amount
Of dissolved oxygen in
The water change as a
Function of temperature?

Why?
PV=nRT

Oxygen Consumption of Fish vs T

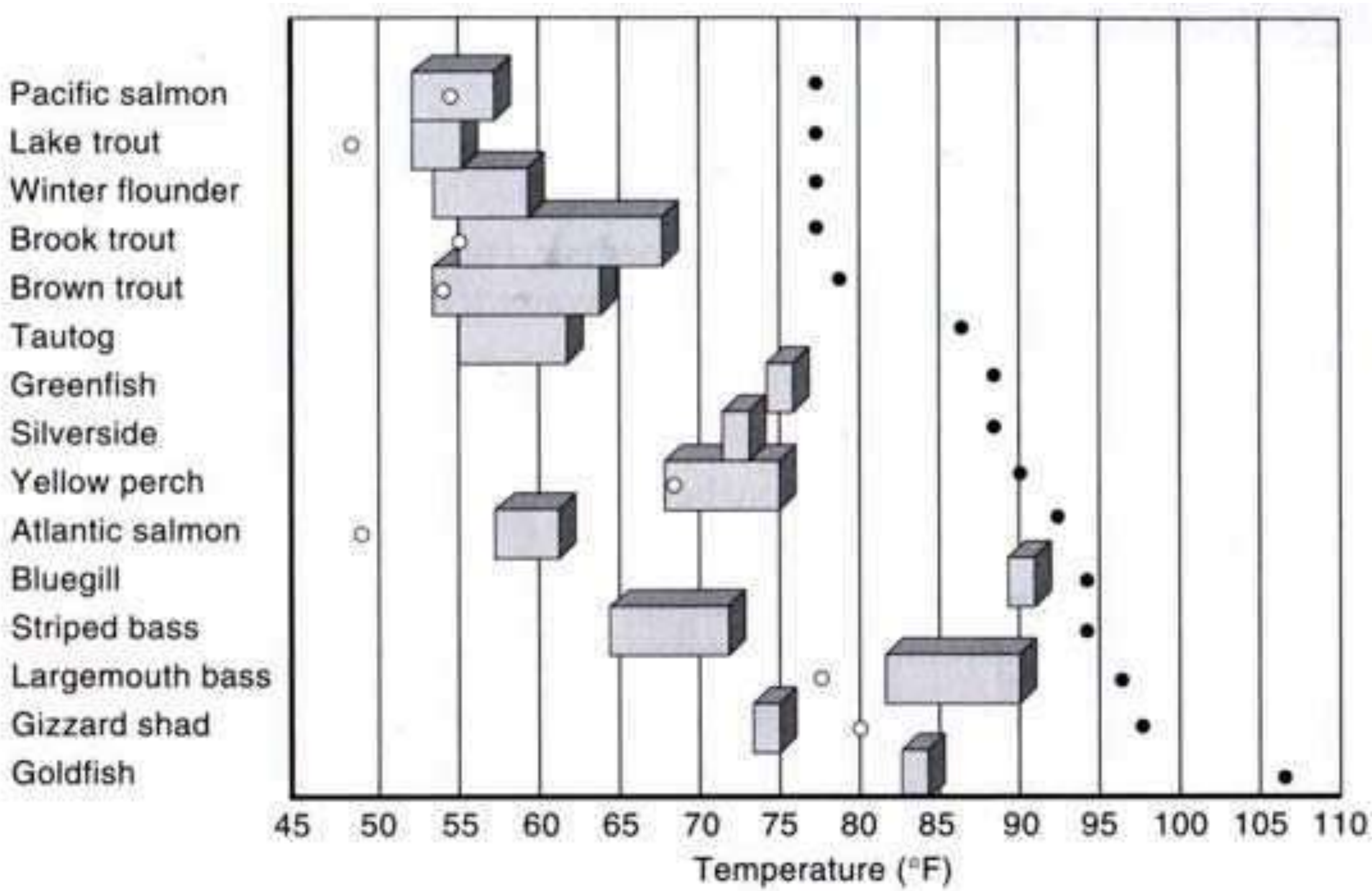


Why do fish need more oxygen
As the temperature of the water
Increases?

Given the solubility of oxygen
In water as a function of temperature
(in the previous slide), what happens
to the fish if the water gets too hot?

Why would it be difficult to publish
This graph?

Fish: Response to Temperature

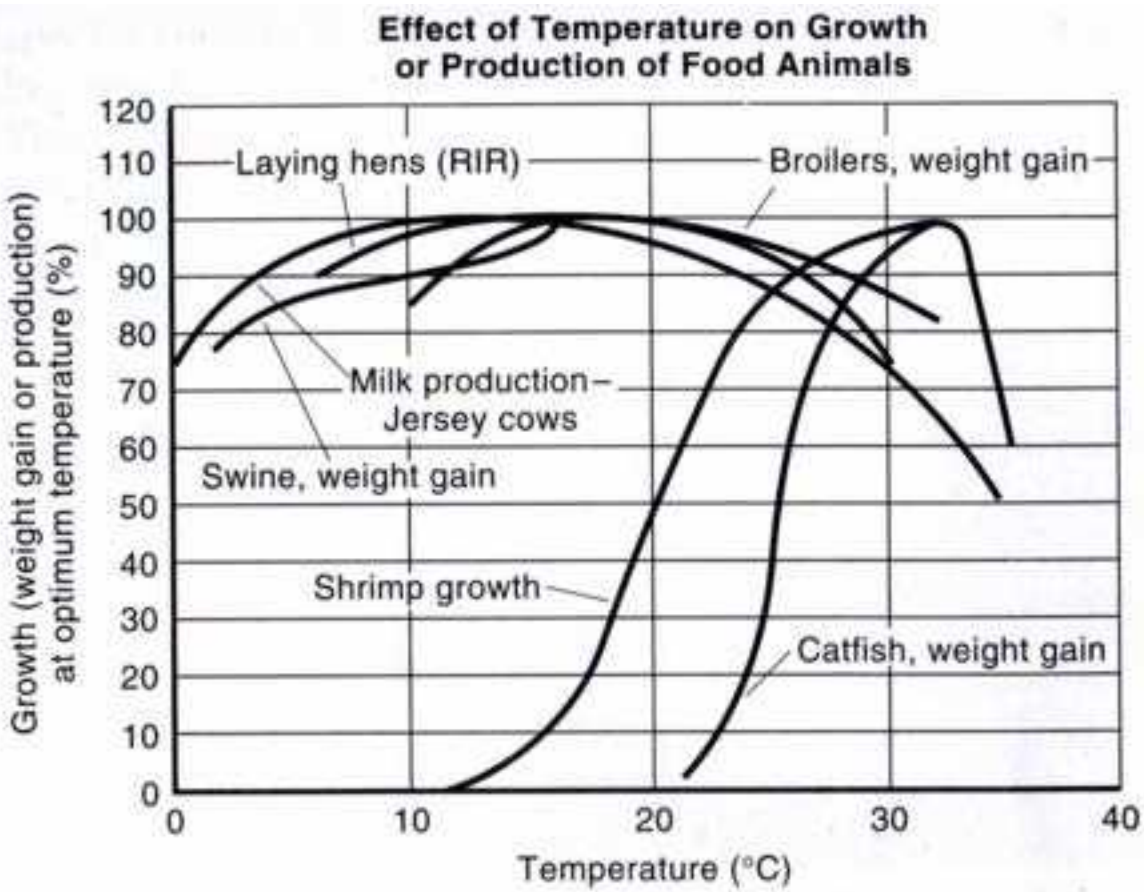


Solid dot: Upper lethal Limit for a Given species

Open dot: Best T for spawning

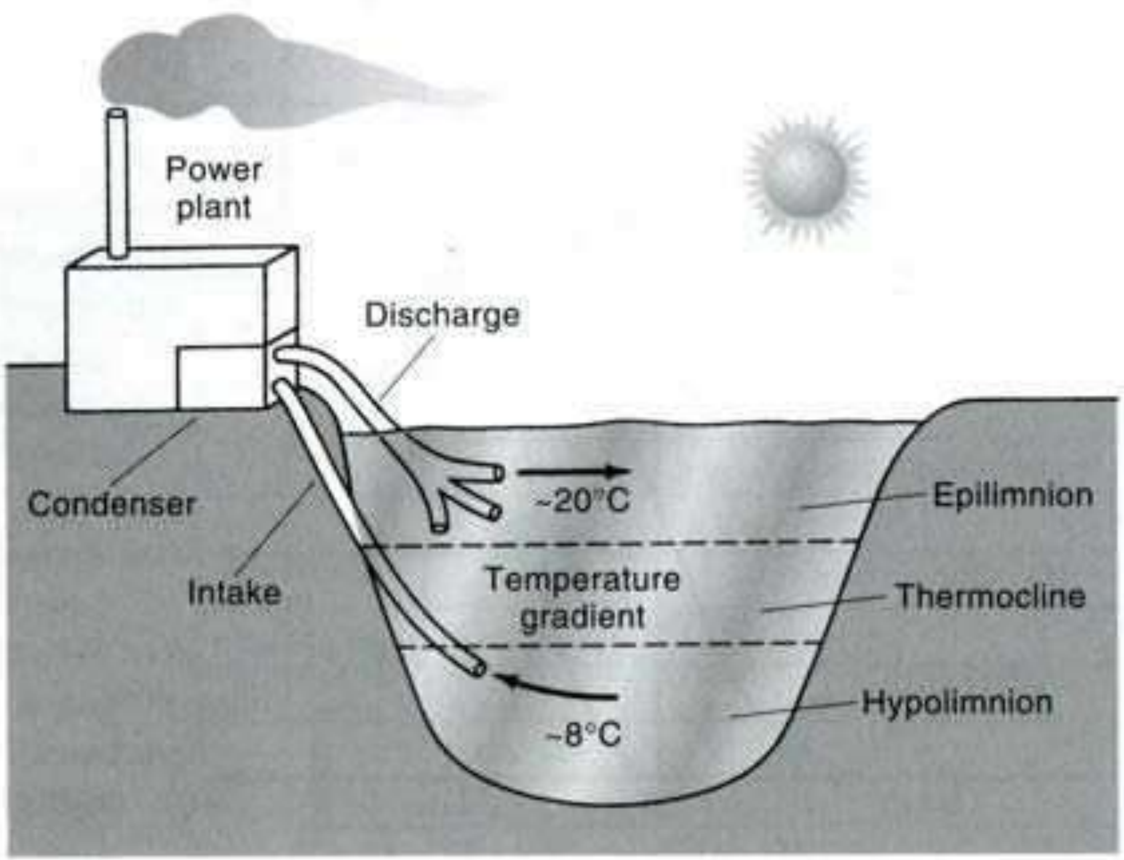
Solid blocks: Preferred Temperature Range

Temperature and Growth of Food Animals



What is the optimum Temperature for Hens, catfish, shrimp?

Thermal Pollution from Power Plants

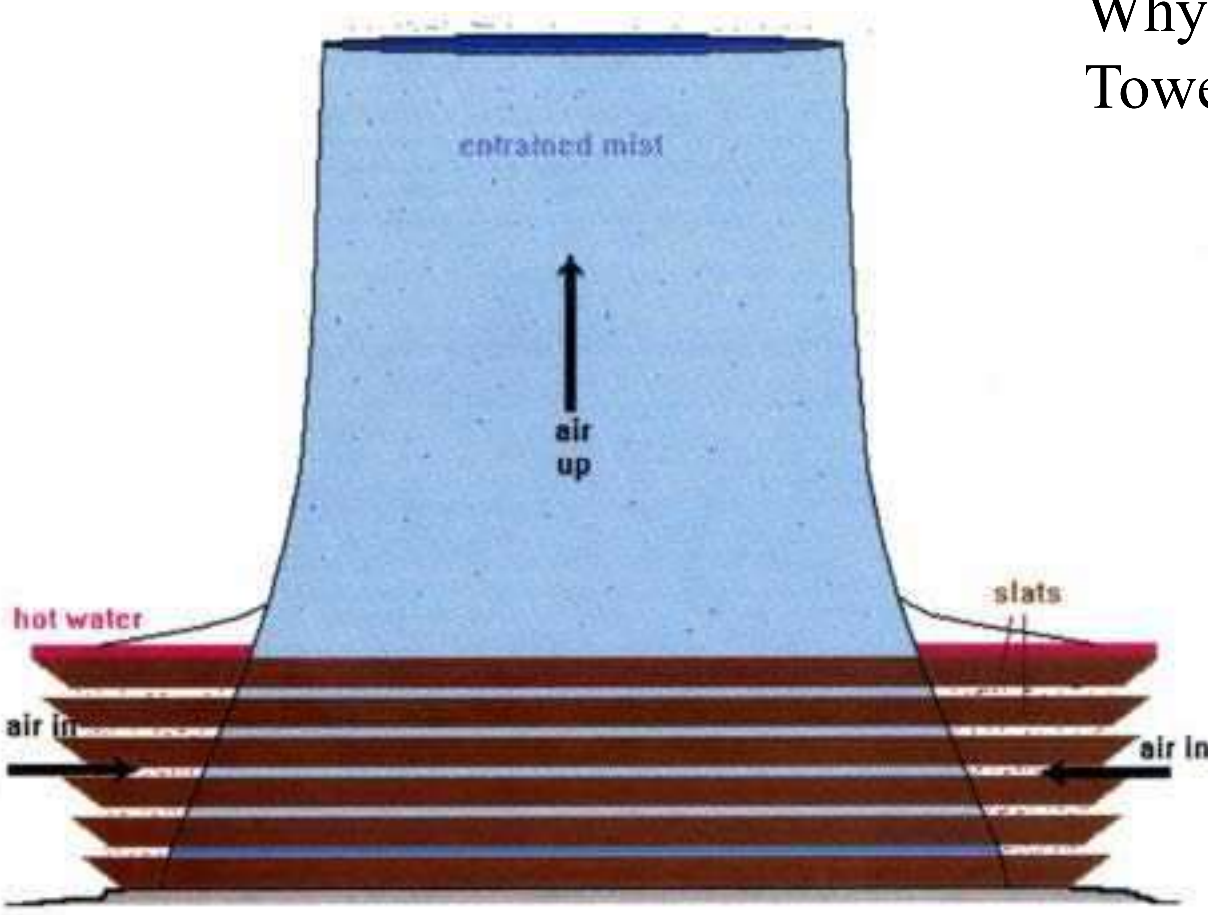


Eutrophication:
Natural aging of
Lakes

Promoted by waste
Heat from power
Plants.

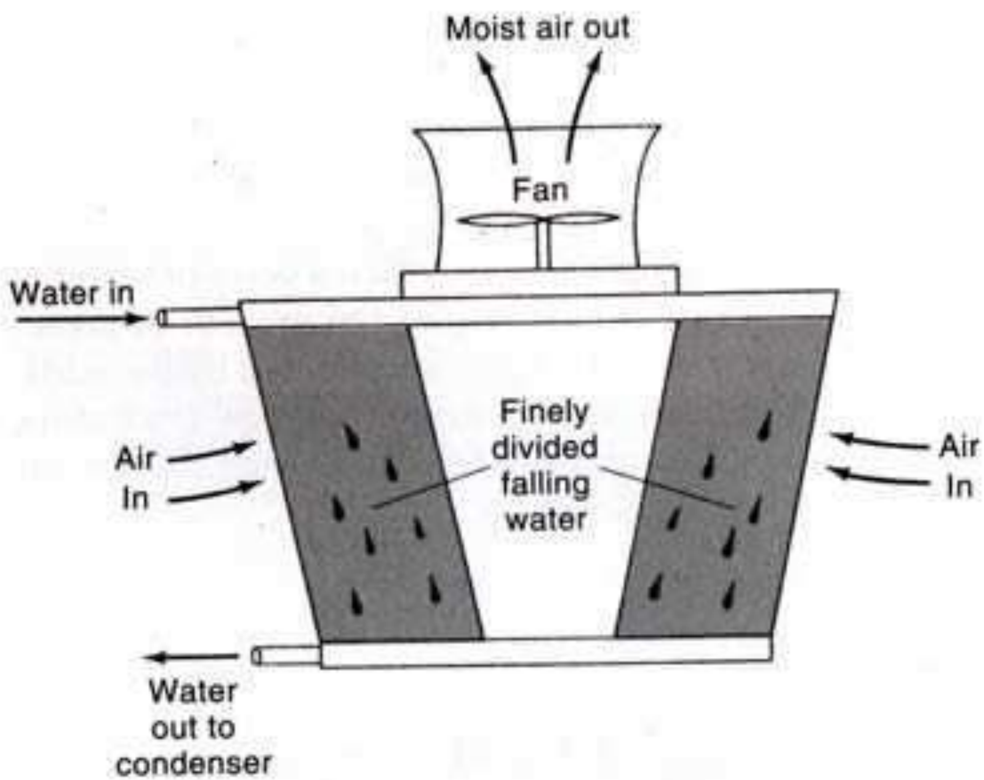
Why?

Natural Draft Cooling Tower



Why does this cooling Tower lack a fan?

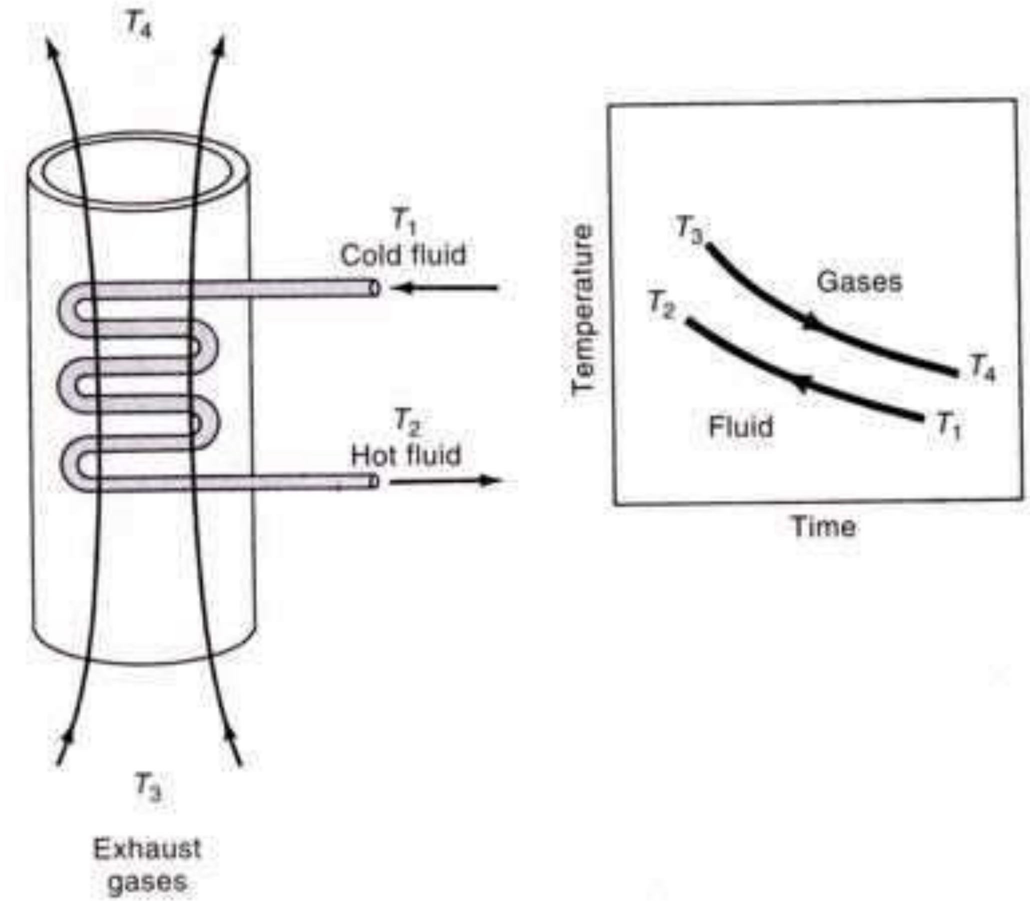
Mechanical Draft Cooling Tower



Why does this tower
Need a fan?

(Active vs Passive
Cooling Tower)

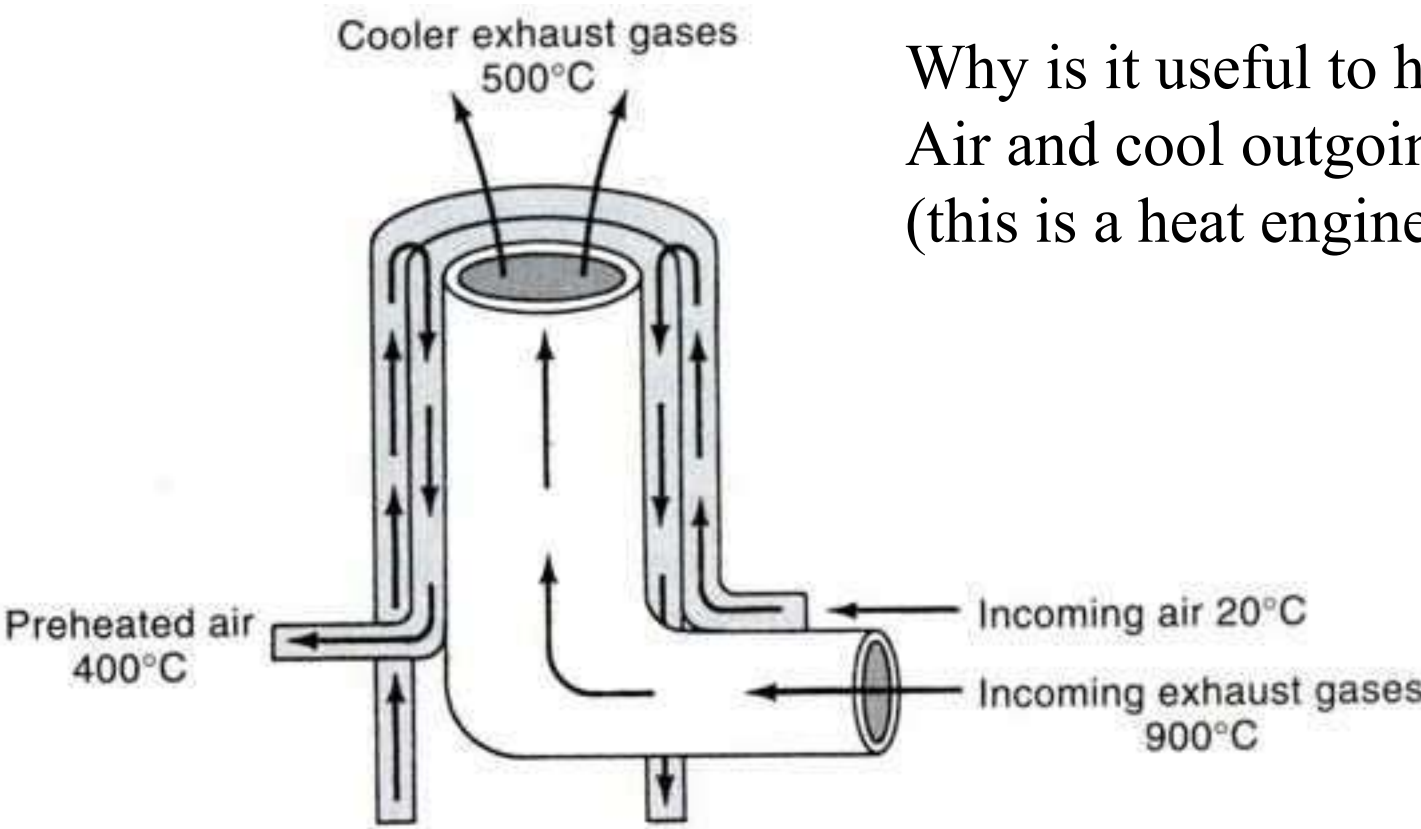
Air to Liquid Heat Exchanger



What is the Heat being Extracted from?

Why?

Recuperator: Also extracts heat



Why is it useful to heat incoming
Air and cool outgoing air
(this is a heat engine)?

Uses of Waste Heat

Cogeneration
Aquaculture
Greenhouse heating
Desalination of seawater
Increase crop growth in cold season
Preheat air
Other??

Presentation On

Air Pollution - Issues and Its Control

SOURCES OF AIR POLLUTION

Major sources of air pollution in Delhi include:

- Vehicles
- Road Re-suspension dust
- Construction Activities
- Trans-state movement of pollutants
- Industrial sources
- Thermal power stations
  - 2- Coal based
  - 3- Gas Based

1.
DUST POLLUTION AT CONSTRUCTION SITES

Pictorial Depiction of Dust Pollution at Construction Sites

Pictorial Depiction of Construction materials lying on roadside

NGT Order With Respect To Compensation On Construction Related Works

National Green Tribunal in OA 21 of 2014 titled "Vardhaman Kaushik Vs Union of India & Ors." regarding Air Pollution in Delhi vide its order dated 10.04.2015 has imposed compensation on construction related works as under:

....(XVII) (b) ***"If any person, owner and or builder is found to be violating any of the conditions stated in this order and or for their non-compliance such person, owner, builder shall be liable to pay compensation of Rs. 50,000/- per default in relation to construction activity at its site and Rs. 5,000/- for each violation during carriage and transportation of constriction material, debris through trucks or other vehicles, in terms of section 15 of the NGT Act on the principle of polluter pay..."***

Measures to Control Dust Pollution at Construction sites

Simple Measures to Control Dust Pollution at Construction Sites

- Put tarpaulin on scaffolding around the area of construction and the building.

- Do not store any construction material particularly sand on any part of the street, roads in any colony.

- The construction material of any kind that is stored in the site should be fully covered in all respects .

- Use of covering sheet to prevent dust dispersion at buildings and infrastructure site, which are being constructed.

•Trucks or other vehicles carrying construction material and debris shall be fully covered and protected.

•The vehicles carrying construction material and construction debris of any kind should be cleaned before it is permitted to ply on the road after uploading of such material.

•Transport construction material and debris waste to construction site, dumping site or any other place in accordance with rules.

•All builders shall ensure that C&D waste is transported to the C&D Waste site only and due record in that behalf shall be maintained by the builders transporters and NCR of Delhi.

•The dust emissions from the construction site should be completely controlled and all precautions taken in that behalf.

•Every worker working on the construction site and involved in loading, uploading and carriage of construction material and construction debris shall be provided with mask to prevent inhalation of dust particles.

•Every owner and or builder shall to provide all medical help, investigation and treatment to the workers involved in the construction of building and carry of construction material and debris relatable to dust emission.

- Fix sprinklers, create of green air barriers.

- Compulsory use of wetjet in grinding and stone cutting.

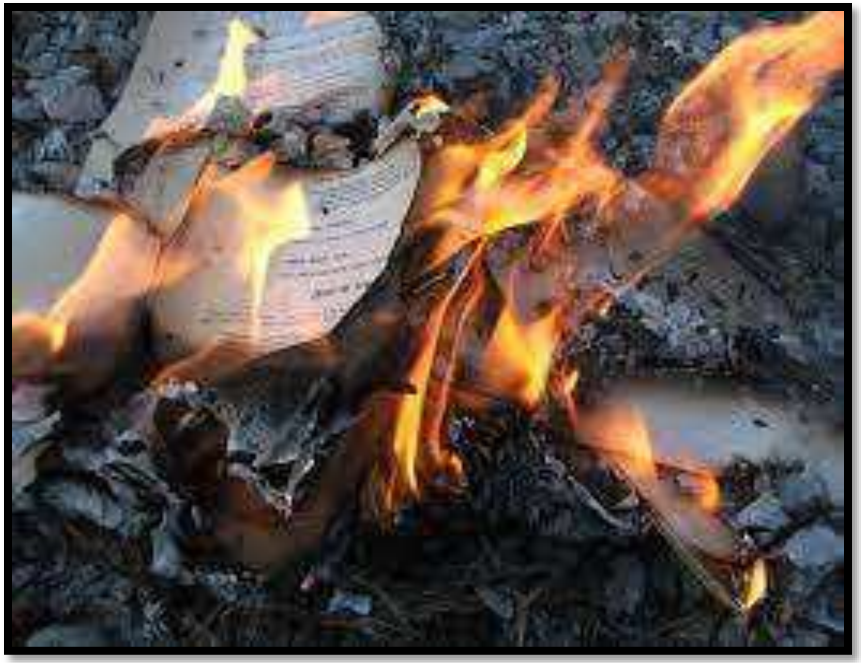
- Put Wind breaking walls around construction site.

2.
POLLUTION FROM OPEN BURNING OF LEAVES, GARBAGE, PLASTIC, ETC

OPEN BURNING OF LEAVES AT PARKS AND GARDENS




Open garbage burning causing smoke and release of harmful gases



OPEN BURNING AT LANDFILL SITES

NGT Order With Respect To Compensation On Burning Of Garbage, Leaves etc

National Green Tribunal in OA 21 of 2014 titled "Vardhaman Kaushik Vs Union of India & Ors." regarding Air Pollution in Delhi vide its order dated 28.04.2015 has imposed compensation on burning of any kind of garbage leaves, waste plastic, rubber, self –moulding compound and such other material in open as under:

*….(5) "..**the person who is found actually burning such material and/or responsible for or abating such burning would be liable to pay compensation in terms of the Section 15 of the National Green Tribunal Act, 2010 for polluting the environment and would be liable to pay a sum of Rs. 5,000, to be paid instantaneously.**"*

SIMPLE MEASURES TO CONTROL BURNING OF LEAVES IN PARKS AND GARDENS

Develop Compost pits at parks and gardens and use the manure.

ALTERNATIVES TO BURNING OF PLASTIC, PAPER ETC.

Recycle and Reuse


Thank you

Biodiversity

Dr Maya Mahajan

Environment and Ecology

- What is Environment?

  Surroundings: Natural and man made

- What is Ecology?

  The study of the interactions between organisms and their environment

Ecosystem

Biotic factors: Living

Abiotic factors: Non living

Biotic factor, Abiotic factor and their interaction with one another

What is Biodiversity?

Bio-diversity means the variety of life on Earth.

the product of four billion years of evolution.

.

"Biodiversity" was coined as a contraction of "biological diversity" in 1985.
A symposium in 1986, and the follow-up book *BioDiversity* *(Wilson 1986),*

It is measured as the

- Species Diversity
- Genetic diversity, &
- Variety of Ecosystems

Species Diversity

Genetic Diversity

Ecosystem Diversity

Terrestrial Ecosystem

- Evergreen forest, Shola
- Grass land
- Dry/Moist deciduous forest
- Alpine forest

Aquatic Ecosystem

- River
- Lake, Pond

Marine/Coastal Ecosystem

- Mangrove Ecosystem, Coral Reef

Domesticated Diversity

- Different crop varieties and livestock breeds

- 50,000 Varieties or Rice in India. Navadanya has identified over 150 sps of rice in Western Ghats

- Warali tribes in Maharashtra grow different varieties of rice for different climatic conditions

- India’s eight breeds of buffaloes represents the entire range of genetic diversity of the world


Yak
Rice and Wheat
Crop Varieties
Mountain Sheep and Goats
Maize
Pulses

Estimation of Biodiversity

For empirical measurement—

2 criteria: Species richness & Species Evenness

Measurement Indices:

Species richness-only number of species.

Simpson index-number and evenness

Shannon index - species richness and number

Alpha diversity—no. of species within the ecosystem

Beta diversity is species diversity between ecosystems; Comparison

Gamma diversity is a measure of the overall diversity for different ecosystems within a region.

Biodiversity Global

- No. of total species - ???? Not known
- estimated total at about 10 million - 30 million
- The number of described species 1.8 million;
- Majority of unidentified species are microbes and insects
- It has taken 4 billion years for this biodiversity to evolve,
- We are rapidly destroying it. (6^{th} Mass extinction- Man made)

India –one of the richest country in the world. Why?

- 8% of words biodiversity in just 2% of earths surface
- Diverse ecosystems and climatic conditions
- 16 major forest types. Forest cover 21%
- One of the 17 mega diversity countries in the world
- Has Global biodiversity hot spots (North east , Western Ghats
- Origin of 30,000 cultivated Plants
- High endemicity (11058 species of plants are endemic)

Centre of Plant Biodiversity

- At least 166 spp of crops and 320 species of wild relatives of cultivated crops are originated in India
- (NY Vavilov-Russian Scientist)
- Rice 50,000 varieties
- Mango 1,000 varieties
- Sorghum 5,000 varieties
- Pepper: 500 Varieties

All the world's buffalo breeds are found in India

All poultry breeds in India-Red Jungle fowl (Wild)

All cow breed originated from India-Zebu (wild)

India – biodiversity

- 45,500 plant species (17,527 flowering plants)
  - 91,200 species of animals, including
  - 57,000 insects (highest number)
  - 4,000 molluscs,
  - 2546 fish,
  - 460 reptiles,
  - 248 amphibians,
  - 1232 birds and
  - 397 mammals
  - 20000 invertebrates

Endemic species in India

- Species, whose distribution is confined to a particular region
- At high risk of extinction
- Endemism-rich areas: NE, NW, and E Himalayas, Western Ghats
- 44 mammals, 55 birds, 214 reptiles, 110 amphibians endemic to India
- 11,058 plants are endemic to India

Endemism in India

- 9% of fish
- 61% of amphibians
- 47% of reptiles
- 14% of birds
- 9% of mammals

Medicinal Plants

- India has 8000 medicinal plants
- Used in 50,000 herbal formulation

- A major source of livelihood
- Special Medicinal plant conservation areas have been established

Biodiversity Hotspots

in India: North East India and Western Ghats

Biodiversity hotspots criteria:

- Regions that harbor a great diversity of endemic species and at the same time be significantly altered by human activities
- Must support 1500 endemic species (0.1% of global)
- Must have lost more than 70% of original habitat
- 25 world hotspots have 44% of all plant species and 35% of all vertebrates in 1.4% of land area

Western Ghats

- One of the Biodiversity Hotspots in India
- More than 5000 sps of Plants
- Bird spp 508
- Mammals 140 (Asian elephants 15,000)
- Butterflies 334
- Fishes 290
- Reptiles and Amphibians 157 each
- Diverse Ecosystems: Evergreen, Shola, Moist and dry deciduous forest, Scrub jungle etc

High Endemism in Western Ghats

- Angiosperms 1500 (38%)
- Butterflies 37 (11%)
- Fishes 189 (65%)
- Amphibians 135 (86%)
- Reptiles 97 (62%)
- Birds 19 (4%)
- Mammals 18 (12%)

Western Ghat Conservation plan by Govt appointed committees

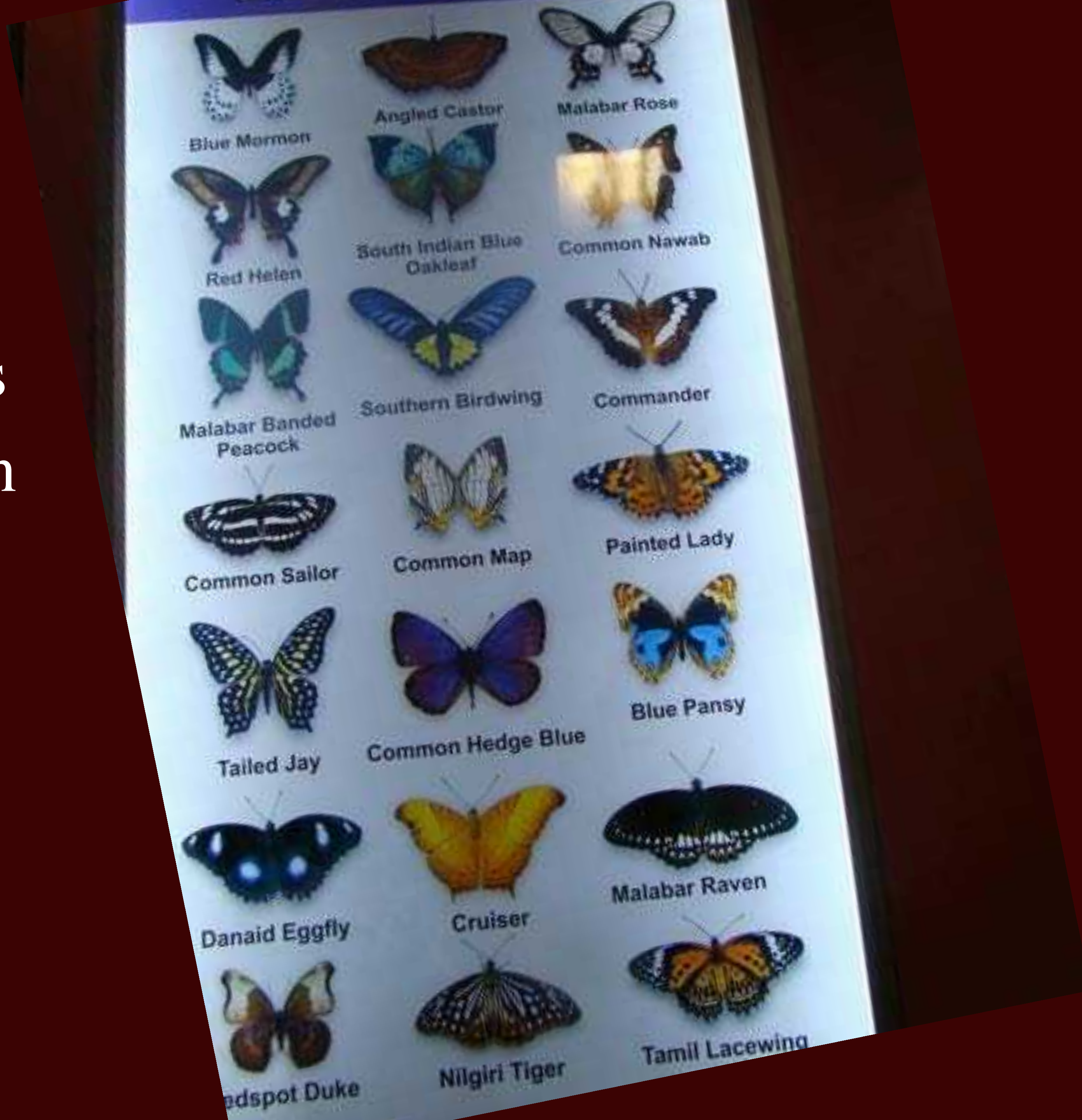
- Western Ghat Conservation plan
- Controversy Between

- Madhav Gadgil report and Kasturirangan report (diluted)

Nilgiri Thar-
State animal of TN- Endangered

Static.panoramio.com

Butterflies in Western Ghats



Nilgiri Biosphere Reserve

- India's first Biosphere Reserve (Siruvani Hills comes under NBR
- Plant sps 3300
- Birds 350 sps
- Butterflies 300 sps
- Reptiles and amphibians 80 sps
- Mammals 100 sps

- **Endangered & Endemic to the area Lion Tailed Macaque, Nilgiri Thar (IIIECE-C)**

Why to Conserve ?

Ecological services:

- Biodiversity provides us food security, water recharge, climate regulation.
- Every species has its own role to play in the ecosystem

Every single species is an integral part of the vast chain of life

No chain is stronger than its weakest link !

Why to Conserve?

- **Economic Value**:

✓ Many species are used as food, fibre, medicine and resource for industrial products & energy. Values of many sp. (and even the species itself) are still unknown.

✓ 25% of all our drugs comes from plants

✓ Around 119 pure chemical substances extracted from about 90 species of higher plants are also used in allopathic

✓ **Vinca** to treat Hodgkins disease and cancer

✓ **Sarpagandha** traditionally used for snake bite, dysentery, nervous disorder, fever, Reserpine, an extract from the plant is now the principal source of material for traquilizers medicine.

Ethical Value

Ethical value:

Every one has a right to live on this planet

Aesthetic Value:.

- Each species adds to the richness and beauty of life on the Earth.
- Ones a species becomes extinct, its gone for ever

Every single day ….

- **We are losing**
  - **300 km2 of rainforest, (1 acre / second)**
  - **40 to 100 species**

Already lost 1 million species,

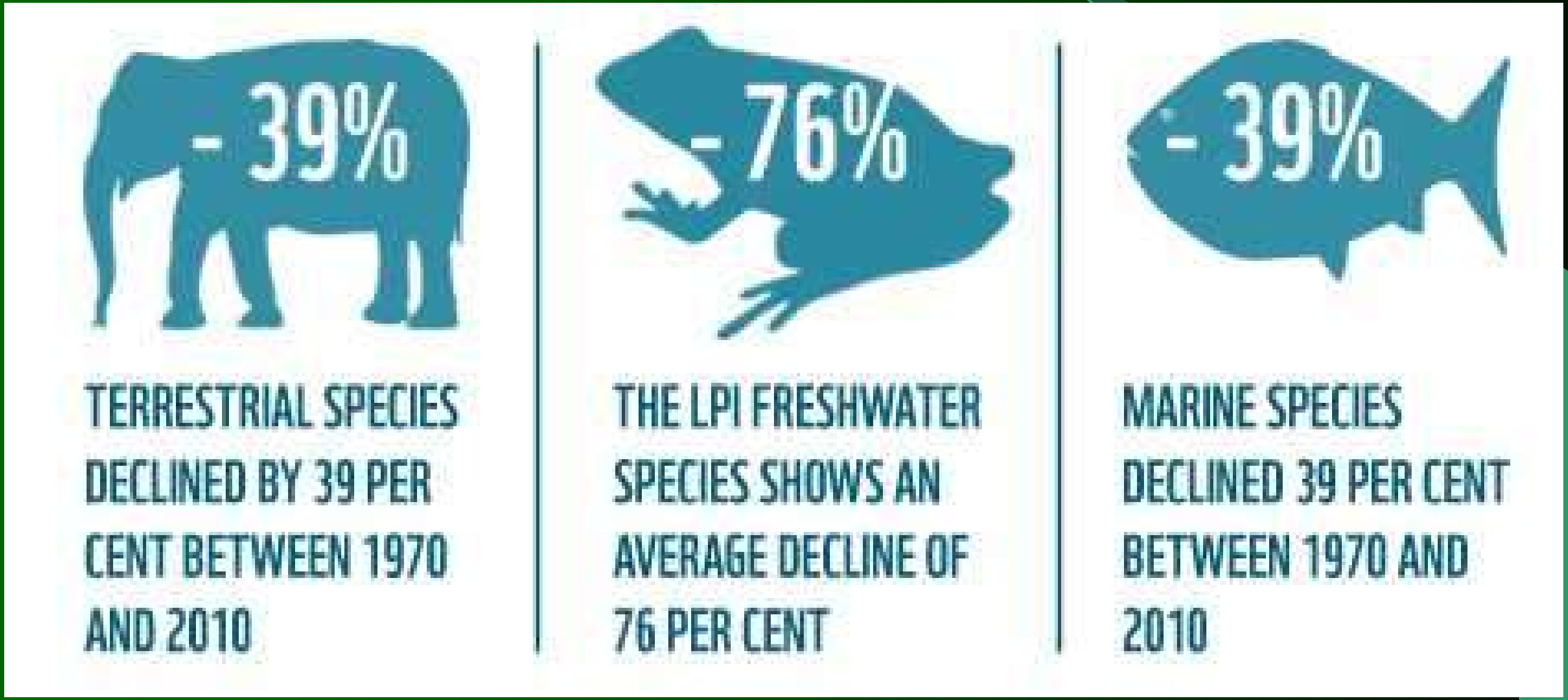
  - **Natural rate of extinction - 1species/ year,**
  - **The present rate is 1species/hour (10,000 times higher)**

  - Tonight the Earth will be a little hotter, its waters more acidic

Living Planet Index 2014

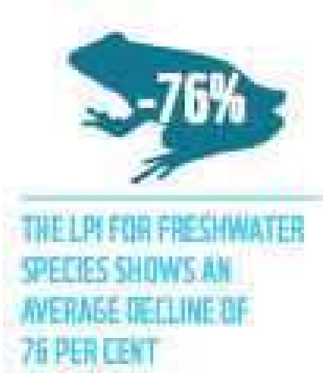
- WWF'S(World Wide Fund) Living Planet Report is a biennial publication that documents the state of the planet-the changing state of the biodiversity, ecosystems and humanity's demand on natural resources.
- Living Planet Index (LPI) 2014, measures more than 10,000 representative populations of mammals, birds, reptiles, amphibians and fish (has declined by 52 per cent since 1970.)
- http://wwf.panda.org/about_our_earth/all_publications/living_planet_report/
- .

Living planet report 2014-WWF



The loss of habitat– particularly for **agriculture**, **urban development and energy production** – continues to be a major threat, compounded by **hunting**.

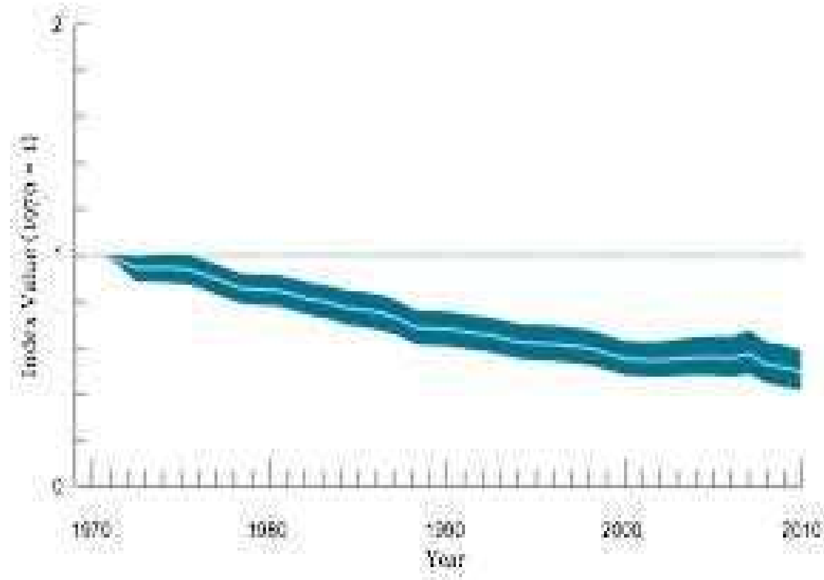
The main threats to freshwater species are **habitat loss, pollution and invasive species.** Changes to water levels and freshwater system connectivity



The steepest declines can be seen in the **tropics and the Southern Ocean** – species in decline include **marine turtles,** many **sharks**, and large **migratory seabirds**

THE LIVING PLANET INDEX 2014

- Biodiversity is declining in both **temperate and tropical regions**, but the decline is **greater** in the **tropics.**



- **Habitat loss & degradation**, and exploitation through **hunting and fishing,** are the primary causes of decline.

Climate change is the next most common primary threat, and is likely to put more pressure on populations in the future

Shrinking ranges

Asian Elephant

Bengal Tiger

Siberian Tiger

Loss of Biodiversity in India

- The Cheetah -spotted big cat is extinct in India
- Pink Headed duck-Extinct
- Jerdon’s courser rediscovered in 1985
- Loktak lake-Manipur Brow antler deer (Dancing deer) Endangered due to habitat loss
- 10% Plants, 20% Mammals, 5 % Birds are threatened.
- 150 Medicine plants disappeared

Endangered Indian Wildlife









Biodiversity loss

- Habitat Degradation
  - All Natural habitats are under threat from human activities
    - Over-exploitation, deforestation, reclamation, mining, roads, dams, Pollution,

  Habitat fragmentation

  Wildlife corridors destruction

  - If current trends continue, humanity will irreversibly alter virtually all of Earth's remaining natural ecosystems within a few decades.

Corridor Conservation

Green Corridor, or Wildlife Corridor, is a patch of habitat that connects populations of wild life, which may become isolated by activities such as forest clearing, fire and so on. **Such corridors are vital for the movement of animals,** requiring large home ranges, such as the elephant and tiger **for re-establishment and breeding**.

For instance, the Project Elephant, launched in 1992 by the Ministry of Environment and Forests, Government of India, has identified **30 State**

Biodiversity loss

- **Introduced Species/ Alien spp**

  -Lantana, Mikenia invasion in Western

  -Rabbit boom Doom story in Australia

Overexploitation of plants and animals

-Frog legs from India exported to Europe and North America- Now it is banned

Global climate change

-Loss of diversity due to extreme climatic conditions

Global warming & Biodiversity

1700 plants, animals and insects species moved pole wards at an average rate about 4 miles per decade in the last half of the 20th Century.

Mass death of Coral reefs because of coral bleaching World wide

Islands in Sunderban sinking,

Threat to Bengal Tiger

Over the past 25 years, penguin populations have shrunk by 33 percent in parts of Antarctica, due to declines in winter sea-ice habitat.

According to a new global study 90 percent of all large fishes have disappeared from the world's oceans in the past half century.

The Golden toad *(Bufo periglenes)* and the Harlequin frog *(Atelopus varius)* of Costa Rica have disappeared as a direct result of global warming

Human-Animal Conflicts

- Examples
  - Leopard at Sanjay Gandhi National Park, Borivili
    - our interference with the wildlife habitats
  - Crop raiding by elephants
    - Destruction of Wildlife Corridors
- Bharatpur (Keoladeo National Park)
    - Wrong conservation decisions avoiding people

Sariska -Tiger

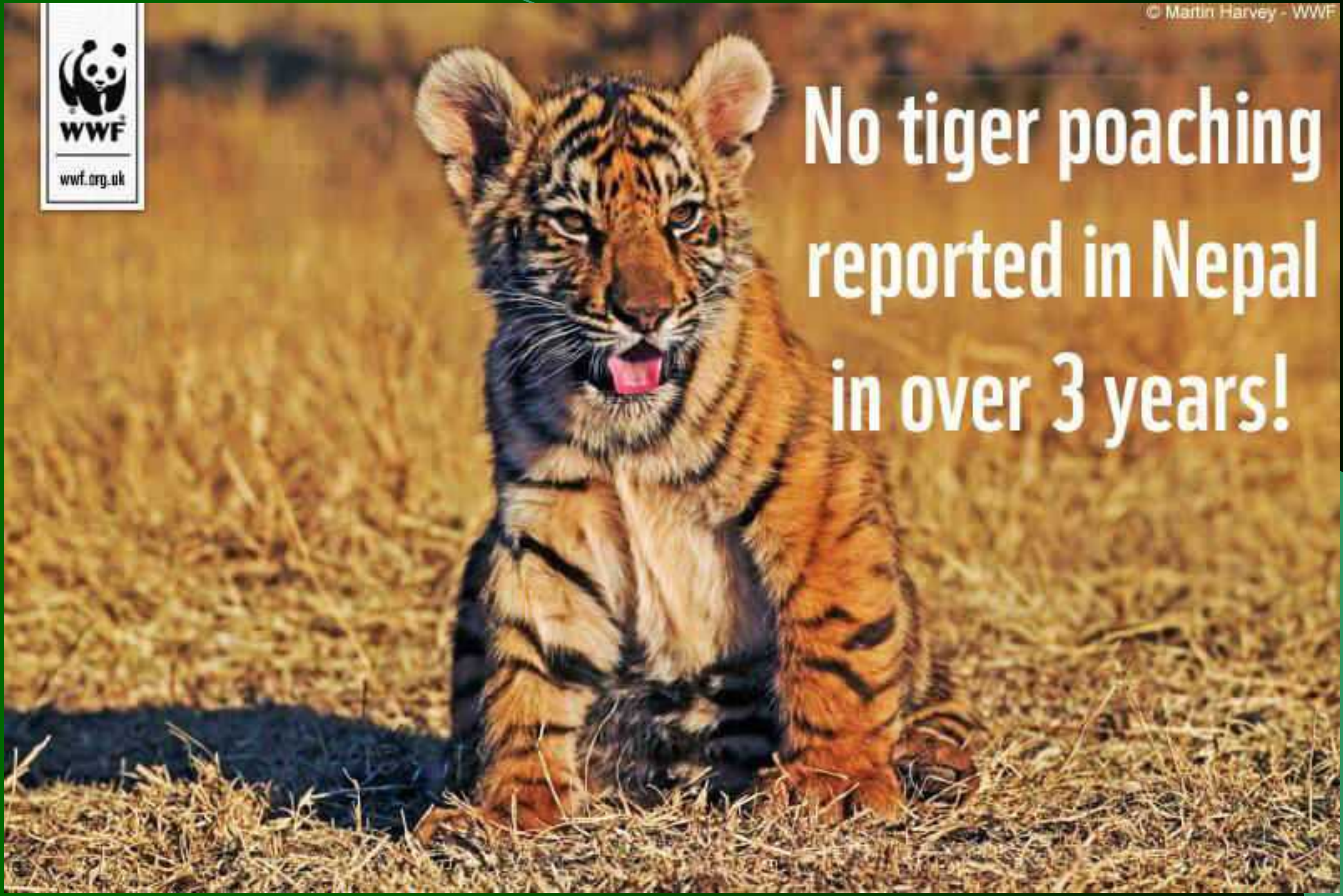
Hunting/ Poaching

- Trade in tiger bone, skin
  - Major factor that threatens survival
  - Used for thousands of years in Asian medicine for treatment of rheumatism

Tiger bone wine

Ivory trade

- Decimated Indian Elephant populations and skewed sex ratio


WWF
wwf.org.uk
© Martin Harvey - WWF
No tiger poaching reported in Nepal in over 3 years!

Tradition of Conservation

- Animal worship
  - Snake, Peacock, Eagle, Rat, Cow
- Sacred groves
  - Vat Vruksha Pooja, Vana Mahotsava
  - Sacred flowers, leaves etc for Pooja
- Bishnoy Community
  - Known to lay down lives for plants/wildlife
- Budhism and Gandhism & Universal Brotherhood concepts
- Emperor Ashoka established Animal Hospitals in 3rd Century BC

Conservation Myth

"Nature conservation is Against development ?"

- Truth
  - Ultimately no development is sustainable without taking care of Nature,
  - On the other hand people participation is vital
- Sustainable Development
  - "Meeting the needs of the present without compromising the ability of future generations to meet their own needs"*

*

Conservation Efforts: International

The Biodiversity Convention

- Focuses on the conservation of biodiversity and on sustainable use of biological resources and equitable sharing of benefits arising from their use. 1992 at United Nations Conference on Environment and Development held in Brazil

The Convention on wetlands of International importance

- The Convention also known as the Ramsar Convention, was signed in Ramsar (Iran). It provides a framework for international cooperation for the conservation of wetland habitats.

International Convention

- World Heritage Convention 1972: biodiversity has to be seen as global heritage
- Convention on International Trade in Endangered species of Wild flora and fauna India 1977
- Bonn Convention on conservation of Migratory species. India 1979

National Conservation strategies

- Indian Forest Act 1927
- Environmental Protection Act 1986
- Forest Conservation act 1980
- Fisheries act 1897, 1984
- Wildlife protection act 1972 Amendment 1991
- Biodiversity Act 2002
- Maritime Zones Act

Conservation efforts

- Chipko movement,
- Silent valley was saved due to Environmentalist (Kerala shastra sahitya parishad) movement
- What if Pooyamkutty hydroelectric project in Kerala comes?

-Submergence of 2400 ha of forest

-174 sp of medicinal plants- loss

-Loss of breeding ground of Elephants

Protected areas (In-situ Conservation)

- National Parks 102
- Wildlife Sanctuaries 515
- Community Reserves 4
- Conservation Reserves 47
- Tiger Reserves (41 sanctuaries & NPs)
- Elephant Reserves (25 ERs)
- Ramsar Sites (25 sites)
- Important Bird Areas (465 sites)
- UNESCO heritage Sites (5 sites)
- Biosphere Reserves (17 BR)
- Project snow leopard (Himalayan states)

Ex-Situ conservation

- Maintaining genetic germplasm in seed banks, zoos, captive breeding sites, gene banks…outside the natural habitat of the species
- Botanical Gardens
- Lead Garden projects
- Central Zoo Authority
- Lab for conservation of Endangered species, tiger, lion, black bug, vulture
- Vulture Conservation Breeding Centres
- Conservation of traditional farming practices, seed banks

SOLUTIONS

- PRESERVE NATURAL CAPITAL:

I. Restore damaged ecosystems
II. Halt the loss of priority habitats
III. Significantly expand protected areas

- PRODUCE BETTER:

I. Reduce inputs and waste
II. Manage resources sustainably
III. Scale-up renewable energy production

SOLUTIONS

- CONSUME MORE WISELY:

I. Through low-Footprint lifestyles
II. Sustainable energy use
III. Healthier food consumption patterns

- REDIRECT FINANCIAL FLOWS:

I. Value nature
II. Account for social and environmental costs
III. Support and reward conservation
IV. Sustainable resource management and innovation

SOLUTIONS

- EQUITABLE RESOURCE GOVERNANCE:

I. Share available resources
II. Make fair and ecologically informed choices
III. Measure success beyond GDP

What can we do?

- Acquire and propagate knowledge on Wildlife & Biodiversity
- Participate in decision making through EIAs
- Respond positively to conservation efforts
- Join hands with concerned organizations such as BNHS, WWF, GreenPeace etc., which are working for Nature Conservation
- Visit Natural forests and Sanctuaries and feel the Nature
- Respect everyone's right to live

What can we do?

- Be Vigilant

  Report to Forest authorities and/or Police of any Forest destruction, Tree cutting, Wildlife trade or hunting. Wildlife (Protection) Act, 1972 prohibits any person from hunting of Wild life and buying of Wild life products.

- Avoid Wildlife products

  Do not buy items made up of Ivory, Fur, leather, etc,
  Also try to convince other people not to buy them either.

- Minimise the use of wooden/paper materials.

- Plant trees/plants /protect forests/habitats/join Nature club of you college, city

FAUNAL DIVERSITY OF THE

AMRITA VISHWA VIDYAPEETHAM, COIMBATORE CAMPUS

Dr Maya Mahajan & Dr M Murugesan

Rich bio-diversity in the Campus

Faunal bio-diversity

- 114 species of Birds
- 91 species of butterflies
- 21 species of mammals
- 17 species of reptiles

Amrita Prakriti Samrakshan Samiti-Activities

Amrita Prakriti Samrakshan Samiti-Activities

World Car free Day 28 Sept 2014


Dr Maya Mahajan
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SAVE NATURE FOR SUSTAINABLE FUTURE

Amma says……….

- *By protecting and preserving wild and domestic animals, trees, and plants we are protecting and preserving nature. Trees, animals, birds, plants, forests, mountains, lakes and rivers- everything that exits in nature-are in desperate need of our kindness, compassionate care and protection.*

- *There is an inseparable bond between man and nature. For man, there cannot be an existence removed from nature.*

Land and Forests

Dr. V.S. Ramachandran
Centre for Environmental Studies

What is a forest?

World view

How other countries define forests

EUROPEAN UNION: Each member country has its own definition. The European Commission has defined forestland as having at least 20 per cent canopy closure (10 per cent in the Mediterranean forests) and a minimum area of 0.5 ha

RUSSIA: Forest includes lands covered by young stands of tree species with relative stocking 0.4 and more, and stands of other age groups with relative stocking 0.3 and more; harvested areas, burnt stands and other forest lands, which are in the process of natural regeneration.

BRAZIL: Forest is defined as an area of land greater than 1 ha, with more than 30 per cent canopy cover and a minimum tree height of five metres.

US: Forestland includes land at least 10 per cent of which is stocked by trees of any size, or land formerly having had such tree cover that will be naturally or artificially regenerated. Forest land includes transition zones such as areas between heavily forested and non-forested lands that are at least 10 per cent stocked with forest trees and forest areas adjacent to urban and built-up lands.

CANADA: Forestland are areas of land where tree canopies cover more than 10 per cent of the total area and the trees, when mature, can grow to a height of more than five metres. It does not include land that is predominantly urban or used for agricultural purposes.

CHINA: Forest means a land having minimum area 0.67 ha, minimum crown cover of 20 per cent and a minimum tree height of two metres.

What is a forest?

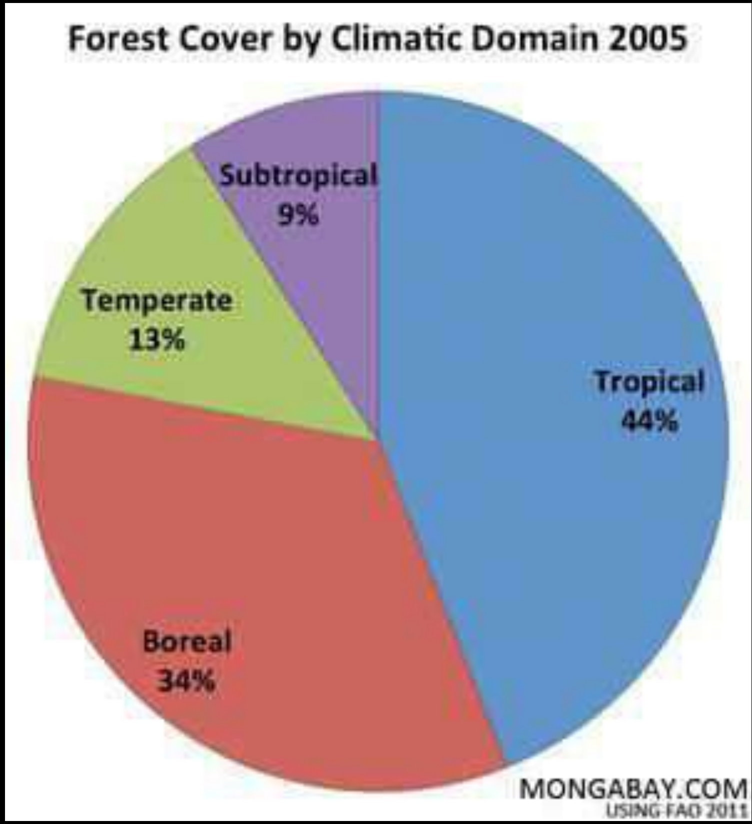
Same forest, different definitions

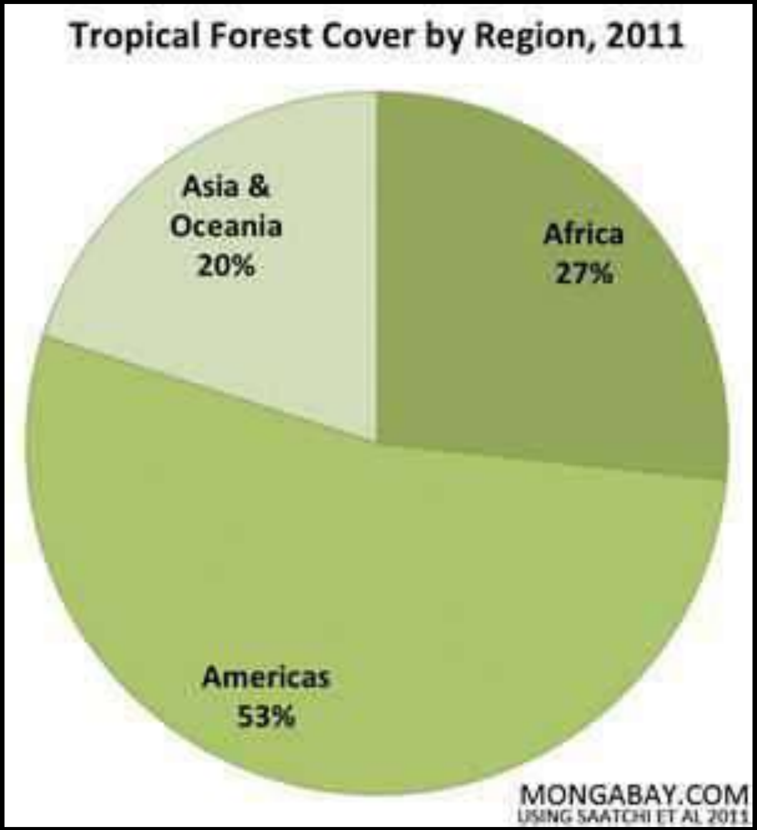
How forest laws and agencies define forests differs substantially

Forest laws/Agency	Definition
Indian Forest Act, 1927 and Forest Conservation Act, 1980	Do not have clear definitions for forest or forestland
Supreme Court order of 1996	Forest should be defined in the "dictionary sense" irrespective of ownership. Also accepted that any land recorded as forests in government records should remain forests
Forest Rights Act, 2006	Defines forestland as land of any description falling within any area and includes unclassified forests, undemarcated forests, existing or deemed forests, protected forests, reserved forests, sanctuaries and national parks
Forest Survey of India	Defines forest as an area of at least 1 ha with a canopy density of 10 per cent as forest; prime forests are classified as very dense and mid-dense with canopy densities of at least 70 per cent and 40 per cent respectively
India's forest definition for Kyoto protocol	A forest is a land area of at least 0.05 ha, with a minimum tree crown cover of 15 per cent, and tree height of at least 2 m

Chakravarthy, A. 2016. Lost in definition. *Down to Earth*, 25 (6): 16-18.

Forest Resources





Forest Resources

Tropical Forests

- Seen as a belt around the globe up to 23^0 on either side of the equator
- They grow in areas receiving annual rainfall >2000 mm or above & with a short dry period (4-5 months)
- Trees reach a height of 45-50

Forest Resources

Sub-tropical Forest

- Seen from 23^0 to 45^0 on either side of the equator

- Winters are relatively warm

- Frost or snow is rare

Forest Resources

Temperate Forest

- seen from 45^0 to 66^0 on either side of the equator
- Region experiences four season, with a well-defined winter
- This contains broad leaved evergreens, deciduous & coniferous plants

Forest Resources

Boreal forests

- Forested areas within the boreal zone
- Made up of cold-hardy trees
  - many of them coniferous (such as pine, spruce, larch & fir)
  - some deciduous (such as poplar & birch).

Forest Resources

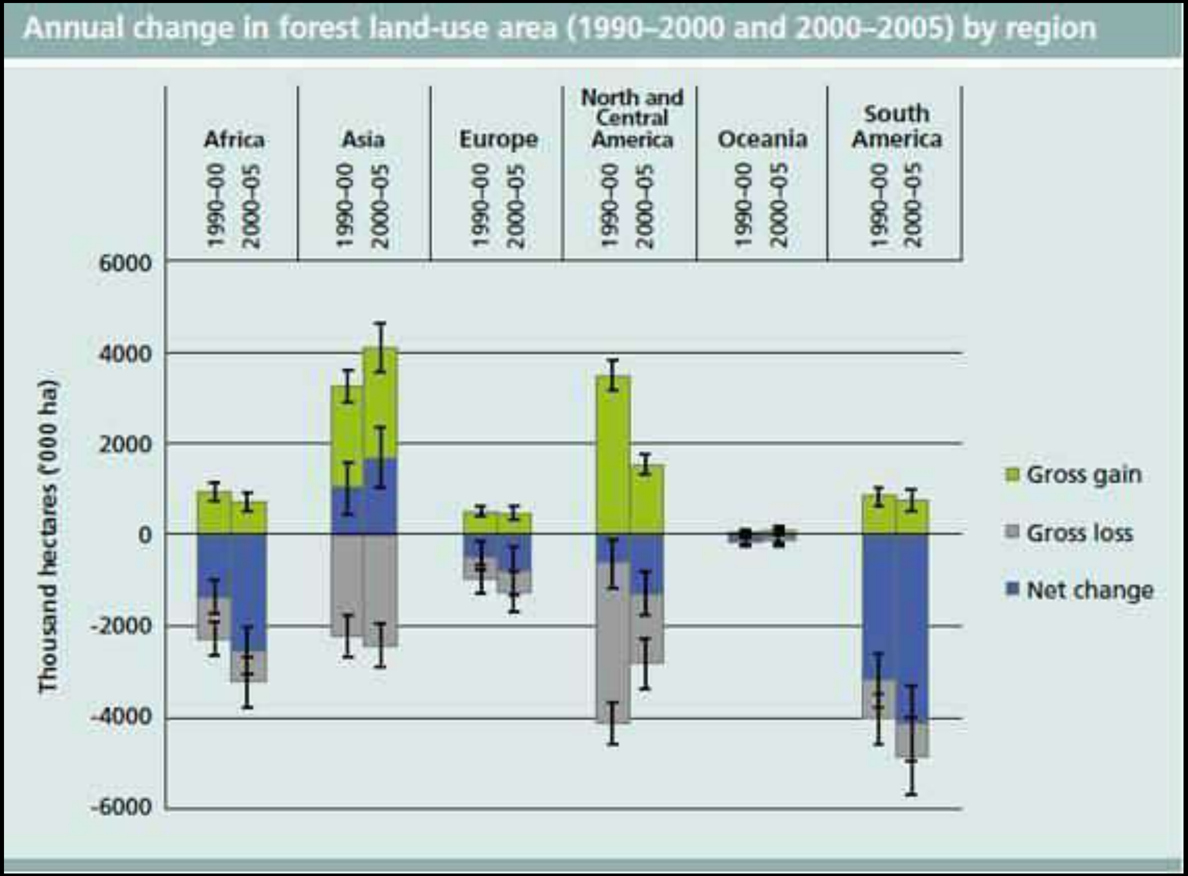
Boreal forests

- The ***boreal zone*** is the broad circumpolar vegetation zone of the high northern latitudes.
  - Boreal zone is more than just forest
  - It contains lakes, rivers & wetlands, as well as naturally treeless terrain such as alpine areas, heathlands in regions where the climate is influenced by the ocean, & grasslands in drier areas

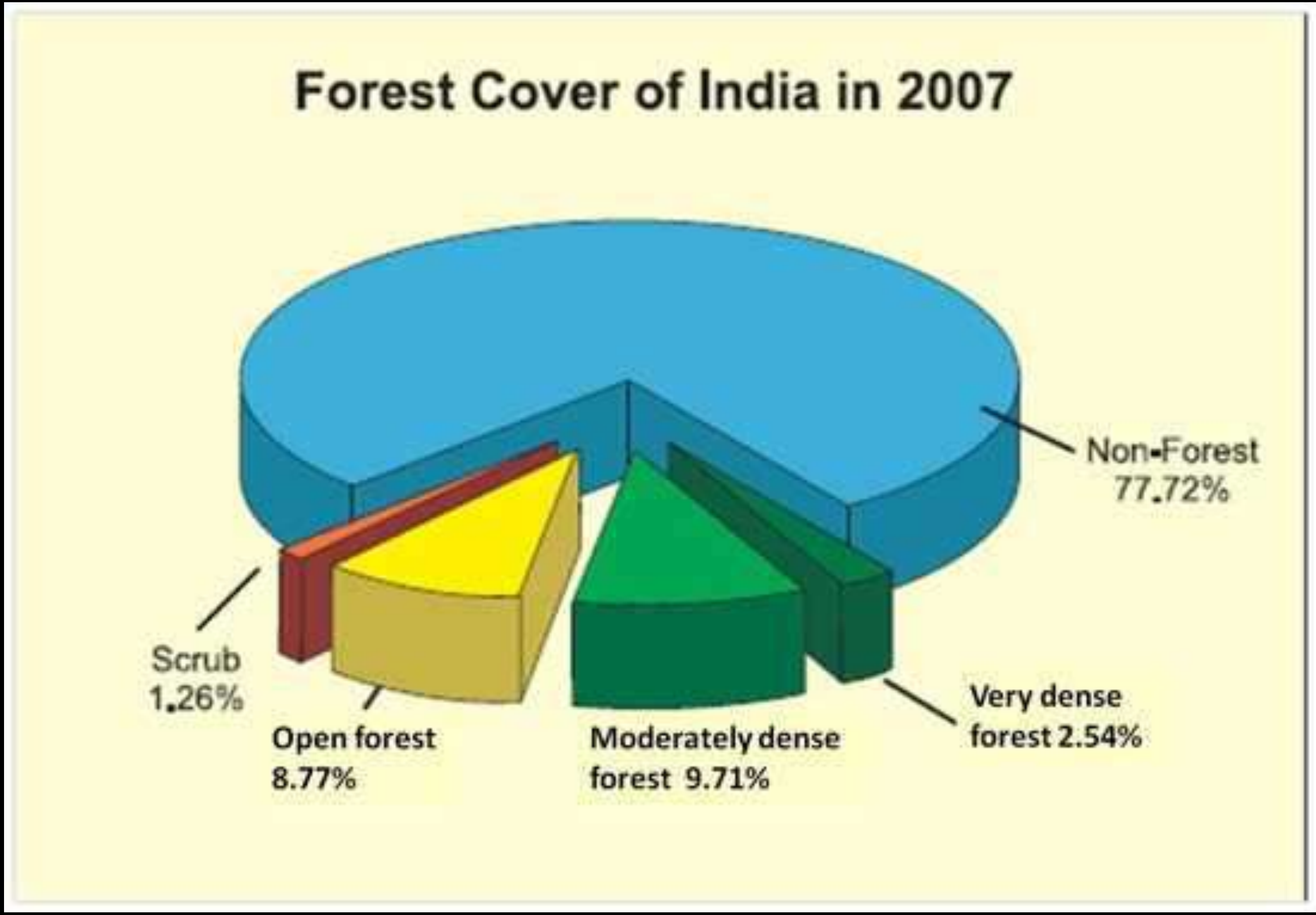
Status of Forest Resources

Status of Global Forests

Status	Forest cover (M ha)	% of forest cover	year	Source
Primary forest cover	1350	36	2010	FAO 2010
Secondary forest cover	2150	57	2010	FAO 2010
Planted forests	264	7	2010	FAO 2010



India’s forest cover



Role of forest/vegetation

- Helps in sequestration/trapping of CO_2
  - For one ton of wood produced 1.8 tons of CO_2 is removed & 1.3 tons of O_2 is released
- Reducing the intensity of rainfall & impact on soil
- Leaf litter & other organic materials on forest floor slow down surface runoff & Provides nutrients & soil carbon (humus) to the soil

Role of forest/vegetation

- Carbon-rich soil absorbs water like a sponge there by enhances retention & storage of water
  - More ground infiltration, better aquifer recharge, slow discharge to streams & better flow of water in rivers throughout the year
- Tropical rainforests produce about 30% of our planet's fresh water

Deforestation/Habitat Destruction: WHY?

Setting up of human establishments

Conversion to agricultural lands

Deforestation/Habitat Destruction: WHY?

Logging or cutting tree for timber needs

Firewood collection

Deforestation/Habitat Destruction: WHY?

Fires in forest – human induced

Charcoal making

Deforestation/Habitat Destruction: WHY?

Cattle grazing in forest

Deforestation/Habitat Destruction: WHY?

Establishment of cash crop plantation

Establishment of timber plantation

Deforestation/Habitat Destruction: WHY?

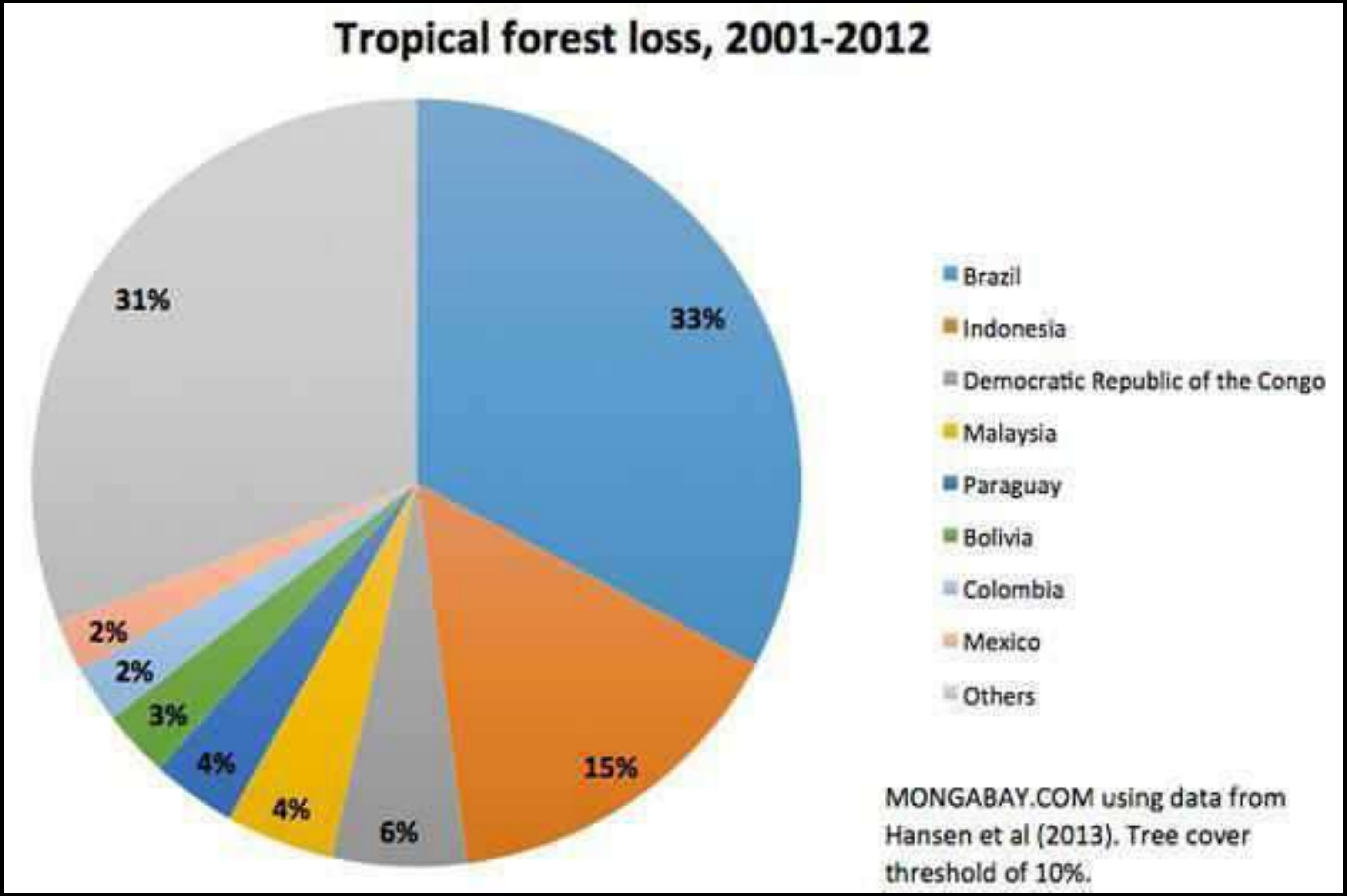
Establishment of ranches

Building homes

Deforestation/Habitat Destruction

- Between 2000 & 2010 estimated deforestation was 13 mi ha per year
- Most deforestation taking place in tropical countries
- In 2010, forests covered about 31 % of world's total land area – about 4.033 mi ha
  - corresponds to an average of 0.6 ha per capita

Deforestation/Habitat Destruction



Deforestation/Habitat Destruction: WHY?

- 48%: Subsistence farming
- 32%: Commercial agriculture
- 14%: Logging for timber & soft wood
- 5%: Fuel wood & Charcoal

UNFCC 2017

Aerial view of deforestation taking place in Indonesia, where forest is getting replaced with oil palm plantation

Status of forest

- Between 1990 & 2010
  - amount of forest land designated primarily for the conservation of biological diversity increased by 35%
  - These forests now account for 12% of the world's forests

Deforestation/Habitat Destruction: WHY?

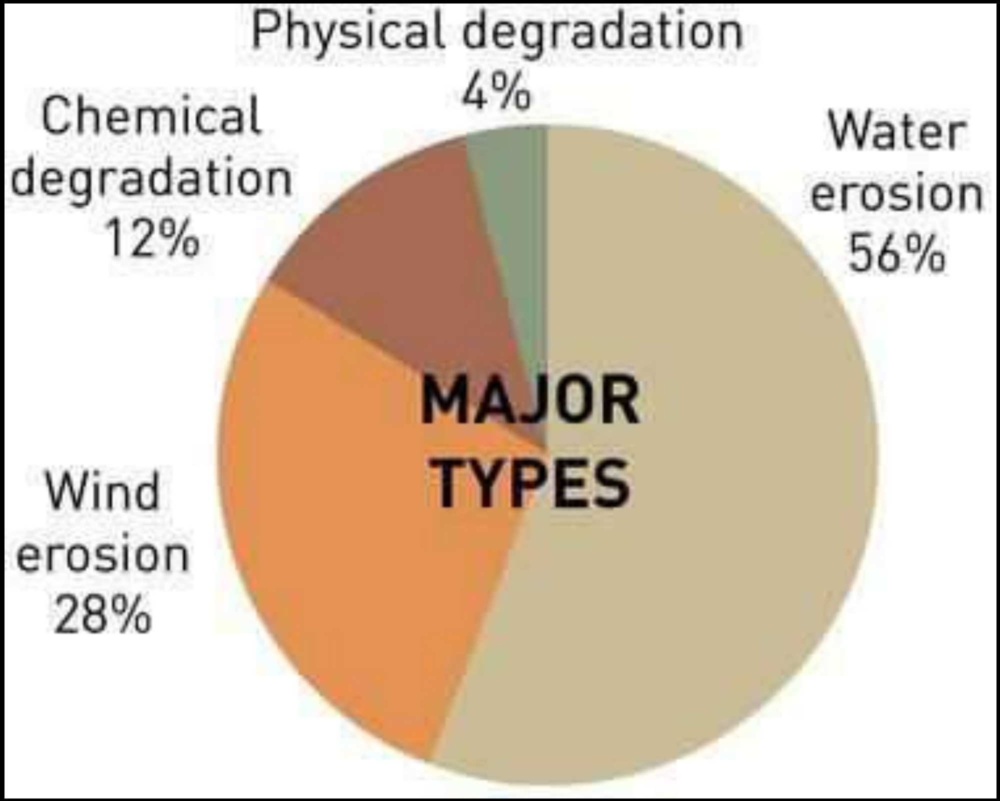
Impact of deforestation

- Loss of biodiversity
- Reduced sequestration of atmospheric CO_2
- Adverse soil erosion
- Disruption of H_2O cycle
- Most often deforested land degrade into wasteland
- Flood & drought
- Enhances impact of climate change

Land Degradation

- ✓ Land degradation is the reduction in capacity of the land to provide ecosystem goods & services, & assure its functions over a period of time
- ✓ Land degradation affects large areas & especially many people in dry land regions
- ✓ About 2000 million ha of soil, equivalent to 15% of the Earth's land area have been degraded through human activities

Land Degradation

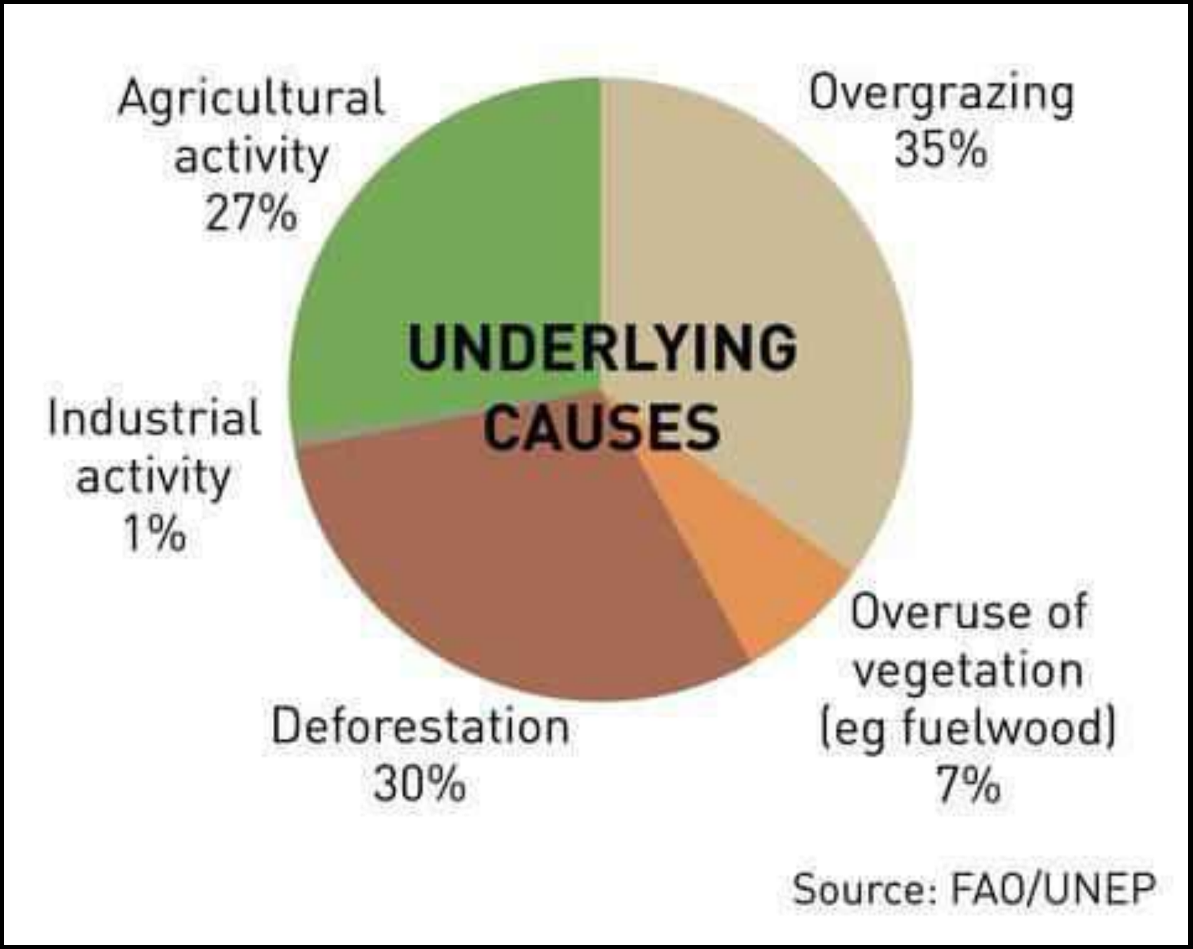


Land Degradation

Soil erosion is a major factor in land degradation & has severe effects on soil functions - such as

- Soil's ability to act as a buffer & filter for pollutants
- Its role in the hydrological & nitrogen cycle
- Its ability to provide habitat & support biodiversity

Land Degradation



Land Degradation

Agricultural activity leading to land degradation:

- Unsustainable agricultural land use
- Poor soil & water management
- Frequent use of heavy machinery
- Improper crop rotation

Natural disasters, including drought, floods & landslides

Land Degradation

- About 24% of global land area has been affected by land degradation
  - area is equivalent to the annual loss of about 1% of global land area, which could produce 20 million tons of grain each year
  - or 1%of global annual grain production

World Watch Institute, 2017.

Land Degradation

Areas undergoing degradation

- Cultivated land: 20%
- Forest: 30%
- Grass lands: 10%

- An estimated 1.5 billion people, or ¼ of the world's population, depend directly on land that is being degraded

FAO Newsroom. 2008

Deforestation & Land Degradation

Land Degradation

Areas undergoing degradation

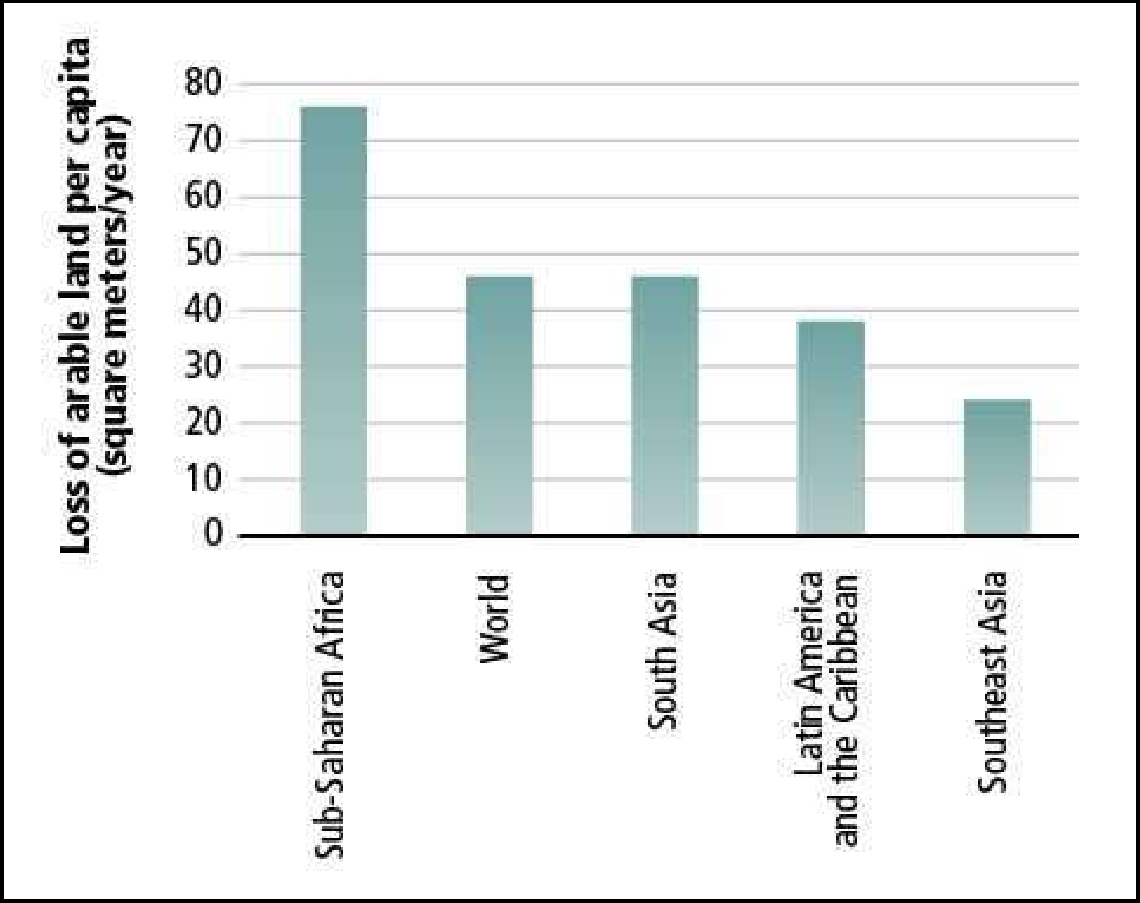
- Among the degrading land
  - 22% is very arid to dry sub-humid areas
  - 78% is in humid regions

- Degradation is being driven mainly by poor land management

FAO Newsroom. 2008

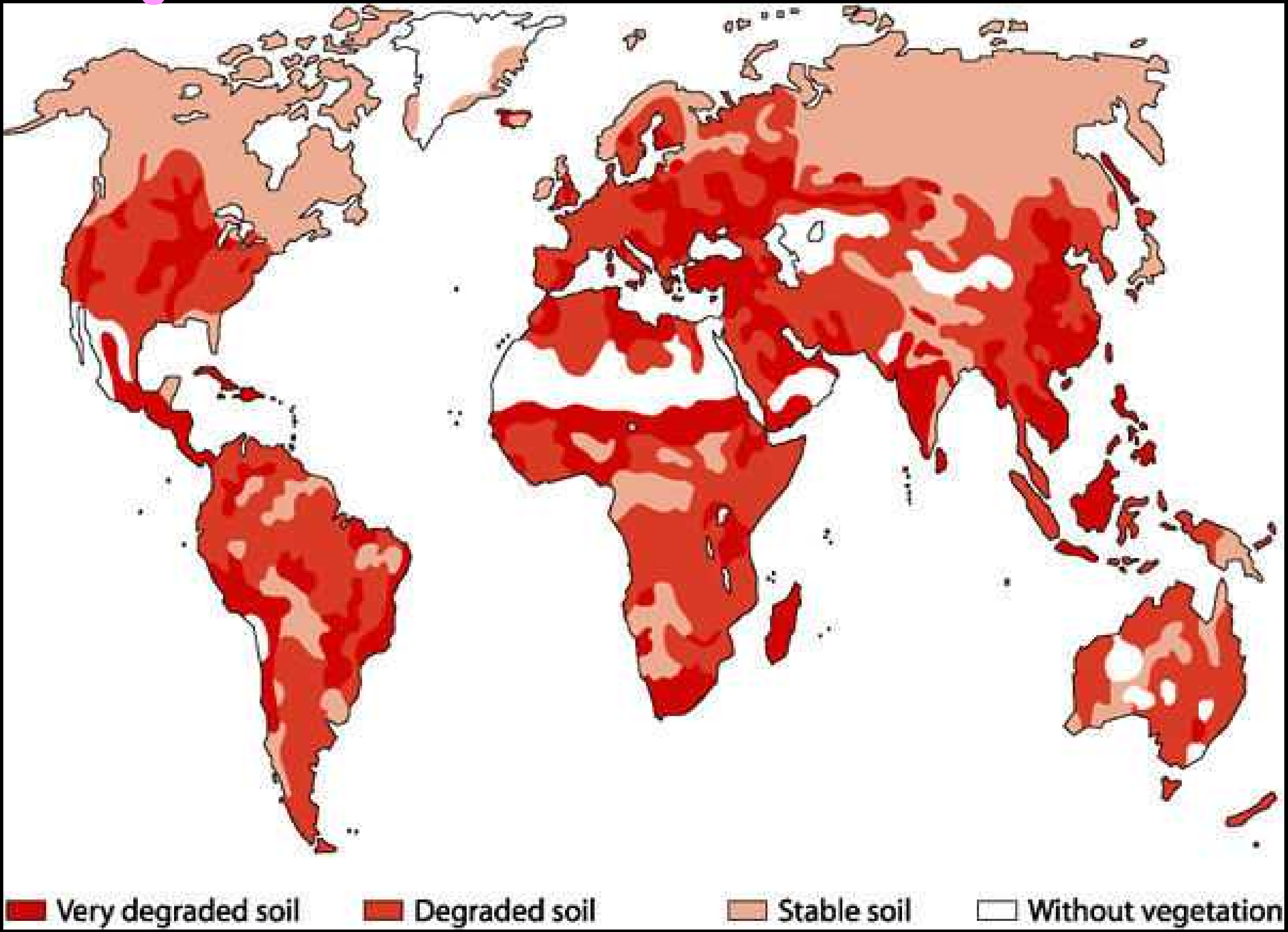
Deforestation & Land Degradation

Land Degradation



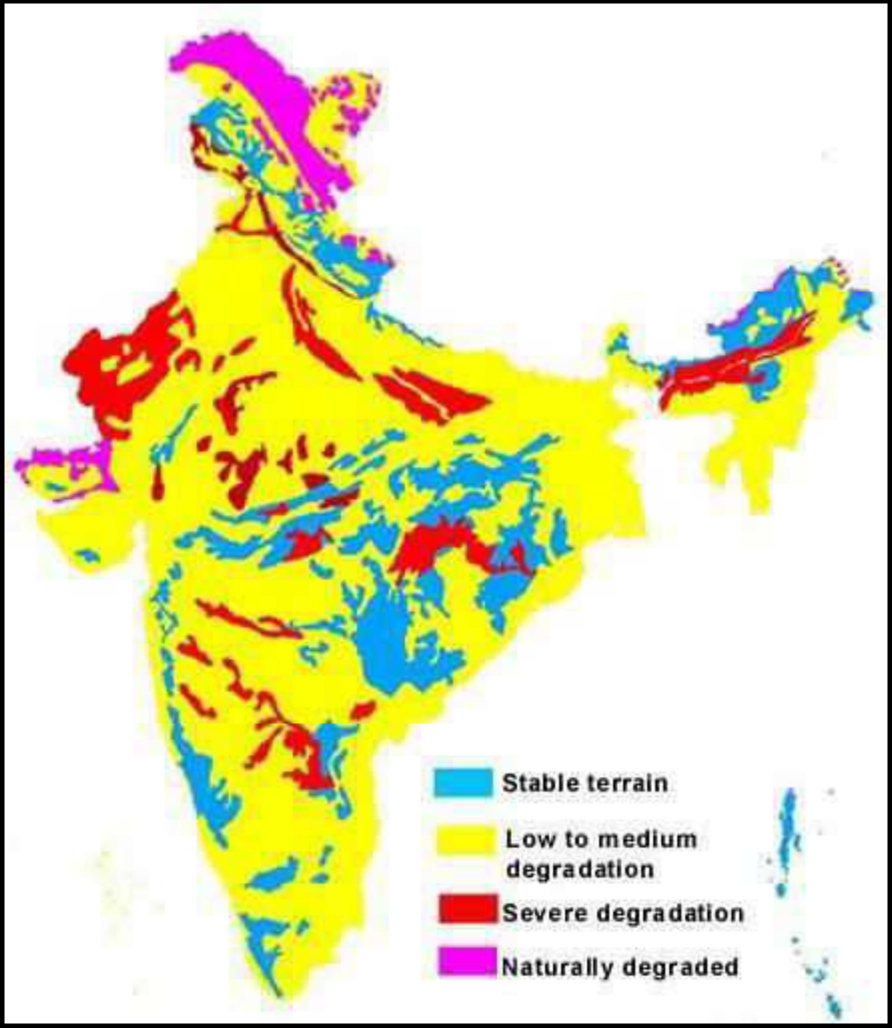
Deforestation & Land Degradation

Land Degradation



Deforestation & Land Degradation

Land Degradation

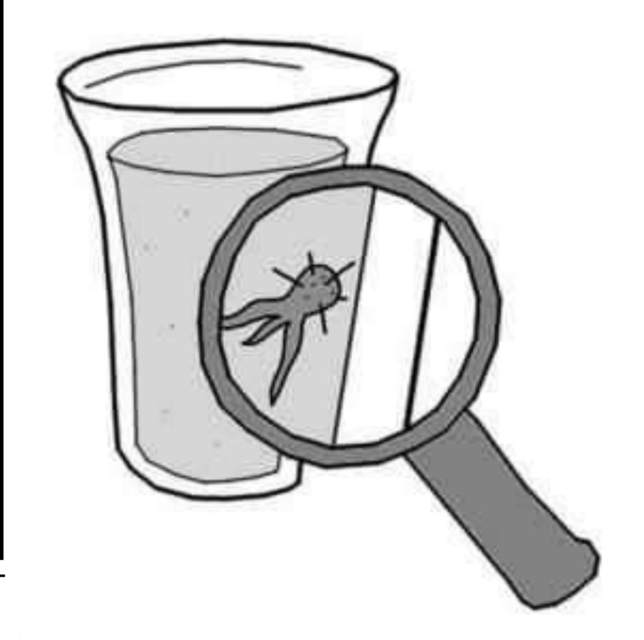


Land Degradation: IMPACTS!!

- Loss of biodiversity
- Salinization
- Loss of fertility/productivity

Land Degradation : IMPACTS!!

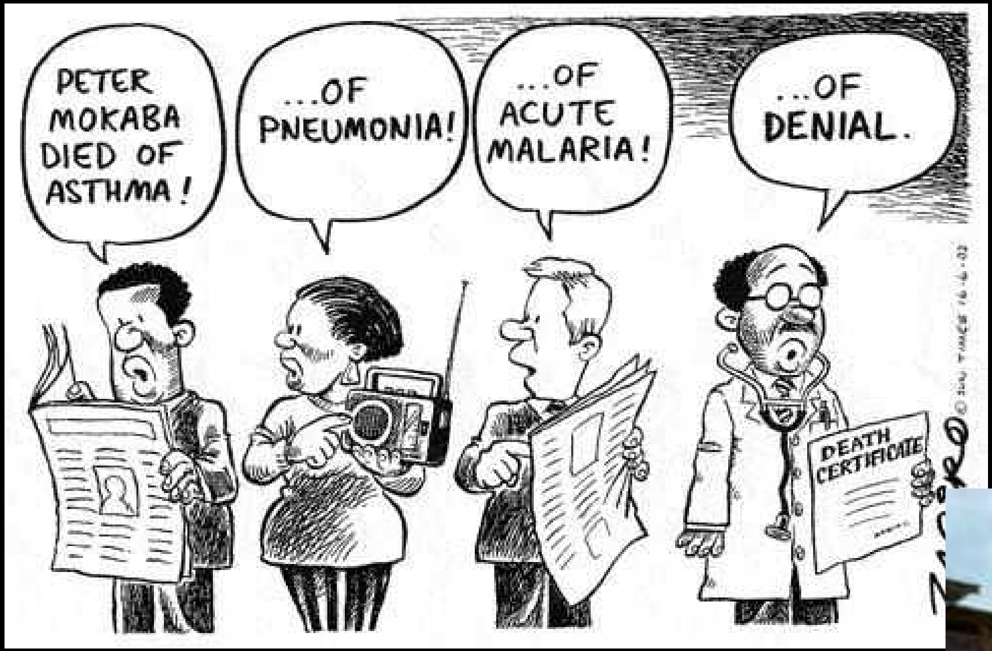
Airborne diseases



Waterborne diseases

Foodborne diseases

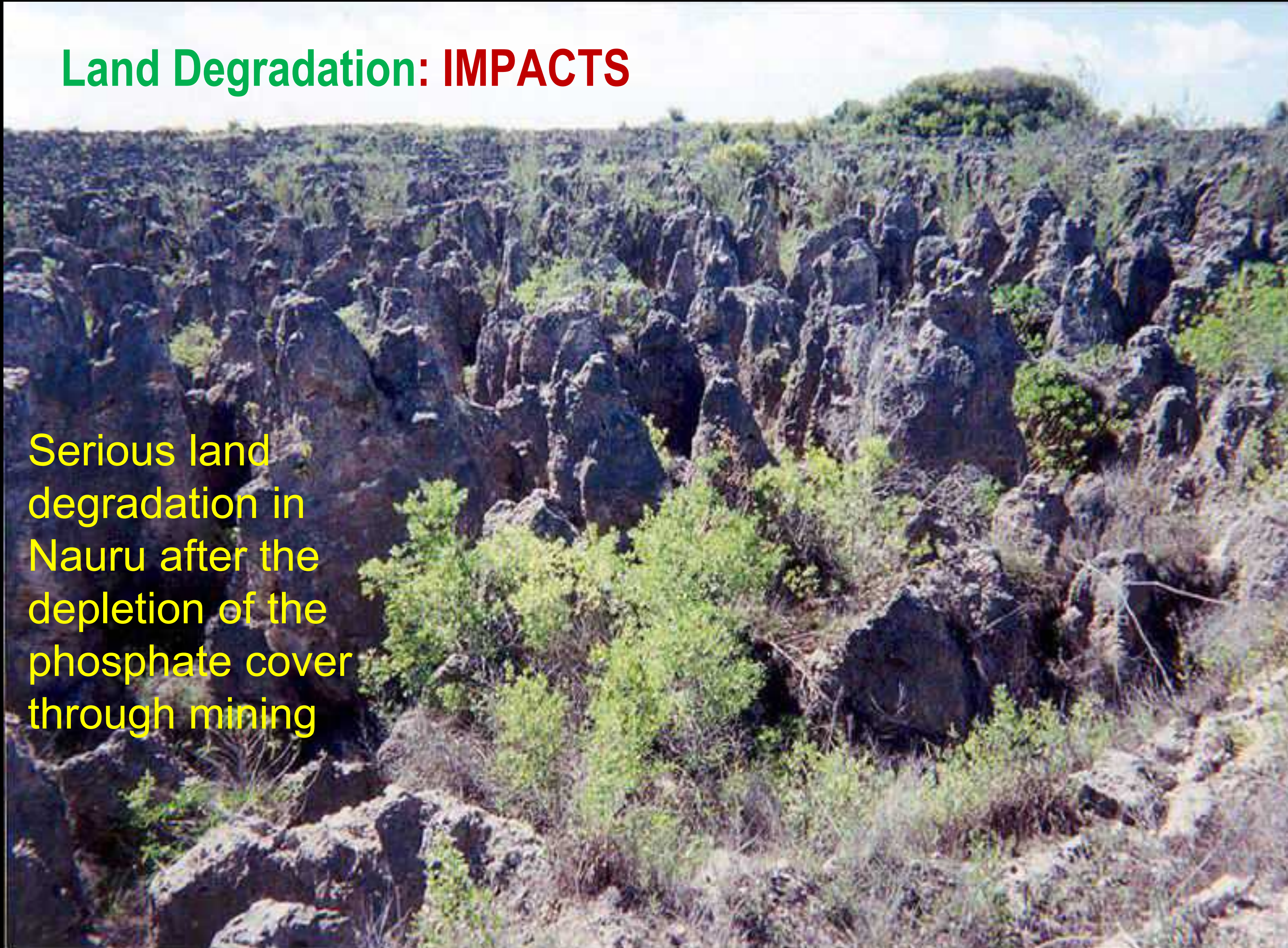
Land Degradation : IMPACTS!!



Spread of communicable diseases

Forced migration of people

Land Degradation: IMPACTS



Serious land degradation in Nauru after the depletion of the phosphate cover through mining

Desertification

- Land degradation in arid, semi-arid (average annual rainfall less than 600 mm) & sub-humid areas is called desertification

- When land degradation happens in the world's drylands, it often creates desert-like conditions

Causes on desertification

- desertification
  - Human factors
    - High pop. + Poor / poverty
      - Over grazing
      - deforest ation
      - Over cropping
    - Impropriate irrigation
      - -salinization
  - Climatic change
    - Global warming
    - Low Rainfall

↓ Soil fertility ,↓ soil degradation &↓ Soil aridity

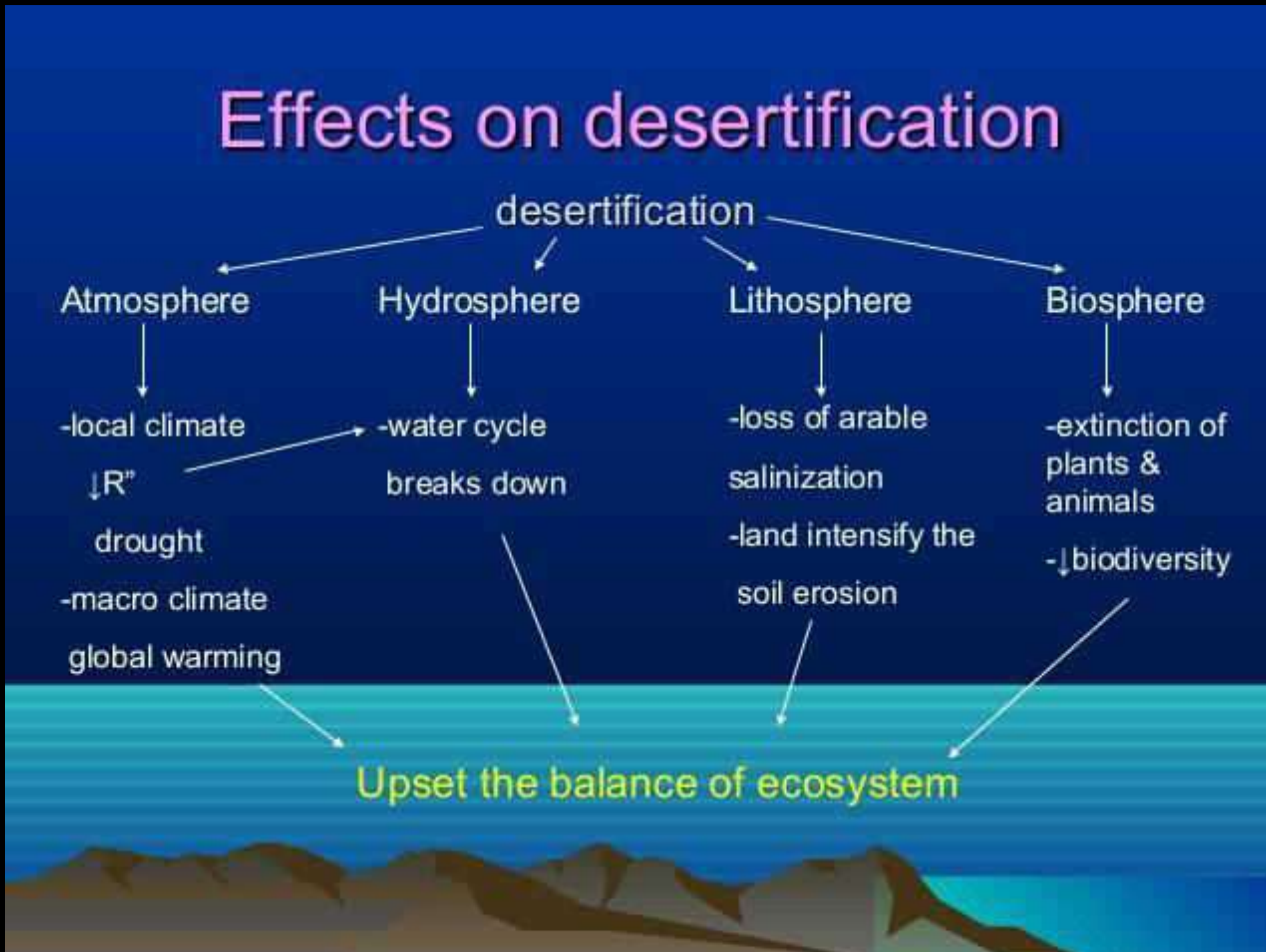
Causes of desertification

Cultivation on marginal lands

Marginal Land

- Arid and generally unhospitable land
- often has poor soil or other undesirable characteristics
- Thus has high risk of crop failure
- usually has little or no potential for profit
- This land is often located at the edge of deserts or other desolate areas

Read more: Marginal Land Definition | Investopedia http://www.investopedia.com/terms/m/marginal-land.asp#ixzz4O4mu1QJi


Effects on desertification
desertification
Atmosphere
Hydrosphere
Lithosphere
Biosphere
-local climate
↓R"
drought
-macro climate
global warming
-water cycle
breaks down
-loss of arable
salinization
-land intensify the
soil erosion
-extinction of plants & animals
-↓biodiversity
Upset the balance of ecosystem

Effects of desertification

- Reduction in ability of land to support life, affecting
  - wild species,
  - domestic animals
  - agricultural crops
  - people
- Reduction in plant cover leading to accelerated soil erosion by wind & water
  - South Africa losing approximately 300-400 million tonnes of topsoil every year

Effects of desertification

- As vegetation cover and soil layer are reduced,
  - rain drop impact & run-off increases
  - percolation decreases

How widespread is desertification?

- About 1/3rd of world's land surface is arid or semi-arid.
- Global warming will increase area of desert climates by 17% in the next century
- Worldwide, desertification is making approximately 12 mi ha useless for cultivation every year

Areas prone to desertification

- About ½ of southern Africa is semi-arid & thus at risk of desertification
- The areas which are known to have deteriorated this century are mainly on the edges of the southern Kalahari

How can desertification be halted or prevented?

- Reduce grazing pressure by reducing number of animals thus allowing plants to regrow
- Protecting the vegetative cover
  - that protect top soil from wind & water erosion
- Integrating land & water management to protect soils from degradation

How can desertification be halted or prevented?

- Turning to alternative livelihoods like greenhouse agriculture & tourism-related activities
- Creating economic opportunities in dry land urban centers & in areas outside of drylands

How can we restore or rehabilitate the ecosystem?

- Preventing soil erosion by
  - Sand fences, stone fences, terracing

- Making soil conditions favourable for plant growth by enriching with organic matter – mulching
  - Mulch (a layer of straw, leaves or sawdust covering the soil) reduces evaporation, suppresses weed growth, enriches soil as it rots, and prevents runoff & hence erosion

How can we restore or rehabilitate the ecosystem?

- Creating green wall/tree wall
  - Planting trees
  - Establishing seed banks - Reseeding in badly degraded areas
  - Reintroducing native species of the area

How can we restore or rehabilitate the ecosystem?

- Watershed management
  - Percolation tanks, contour bunding, check dams
  - Water harvesting using locally available/adapted techniques & storage
- Cooking Fuel: Planting trees for firewood

Unit - 2 Principles of Ecology

Principles of Ecology

- **Segments of the Environment**
  - Atmosphere, Lithosphere, Hydrosphere, Biosphere
- **Ecosystem: Biotic and Abiotic Factors**
- **Organization of the Ecosystem**
- **Types of Ecosystems**
- **Structure of the Ecosystem**
  - Ecological Pyramids
- **Functions of Ecosystems**
  - Productivity
    - Food Production

- Energy Flow
    - Food Chain and Food Web
- Nutrient Recycling
    - Biogeochemical Cycles - Water Cycle, C, N, P, S Cycles
- Development and Stabilization
    - Community Associations
    - Community Adaptations
    - Ecological Succession

- **Ecosystems Services**
- **Economical values of Ecosystem Services**
- **Threats to Ecosystems**

Ecology - *Ikos*—dwelling; *Logos*—study

Study of the inter-relationships among living beings and their interactions with the physical environment[ref].

Autoecology - study of an individual species including behavior, adaptation and interaction with environment[ref]

Synecology - study of communities and their interactions with the environment[ref]

The Physical and biological habitat surrounding us is the in Environment, it has a four segments[ref]

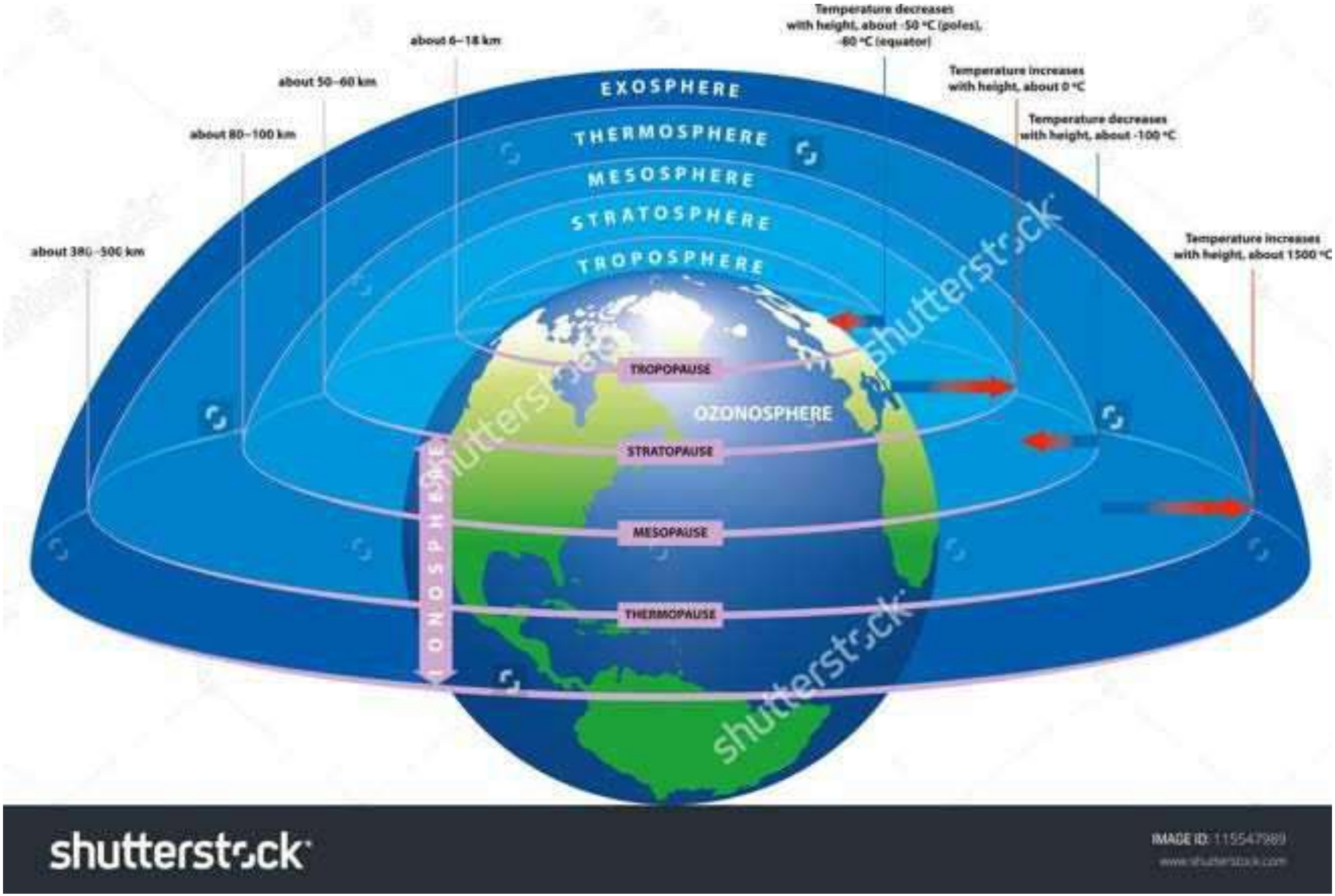
Atmosphere: small reservoir, efficient transporter.

Lithosphere: Earth's Crust, rocks, minerals. Huge reservoir, less transport (conveyer), Pedosphere: soil

Hydrosphere: oceans and water, huge reservoir and transporter

Biosphere: small reservoir, moderate transporter; huge impact on the environment.

Atmosphere



http://view.ge/page/sience/15-atmosphere-of-earth?lang=english

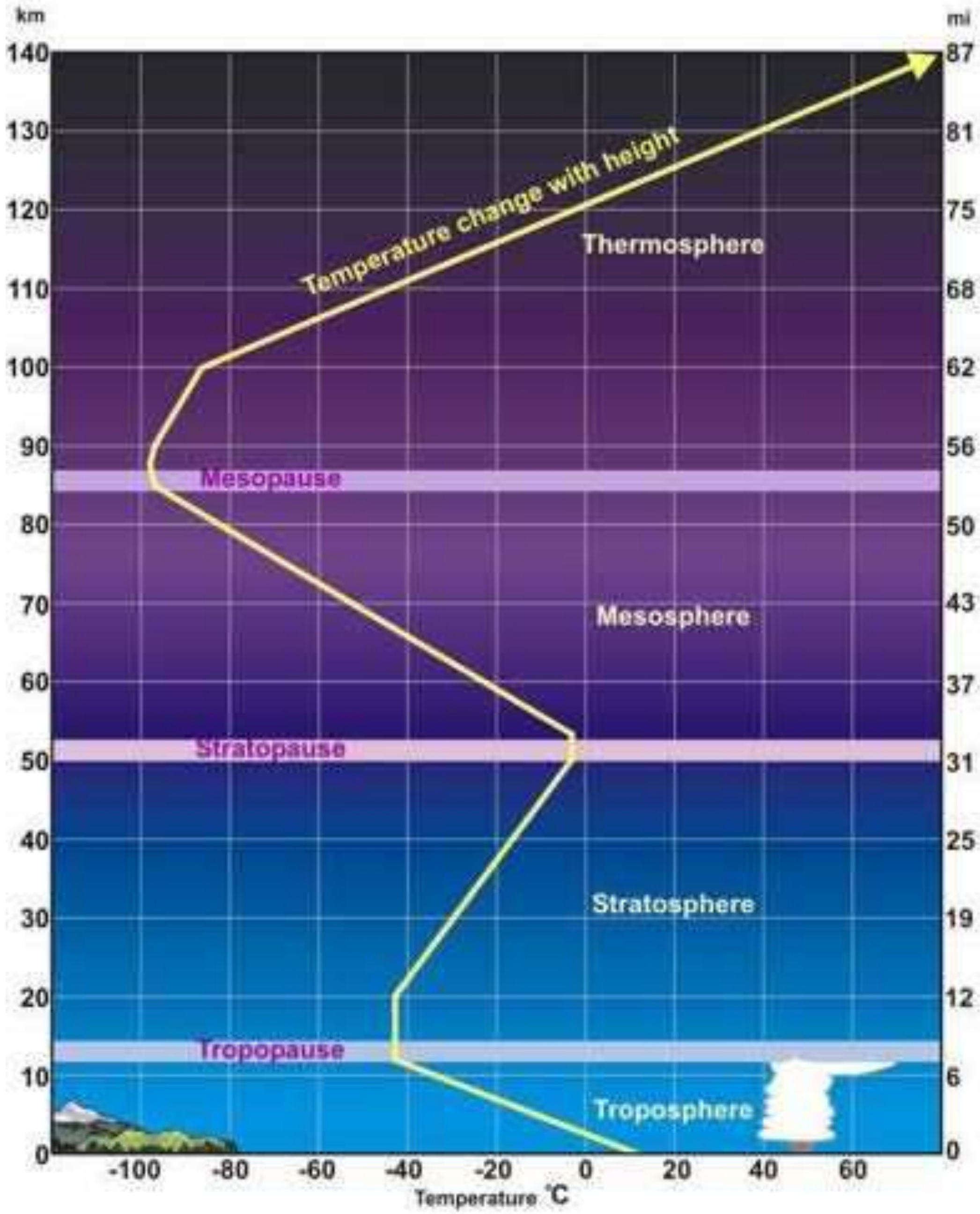
Exosphere: 500 – 1000 km up to 10,000 km,

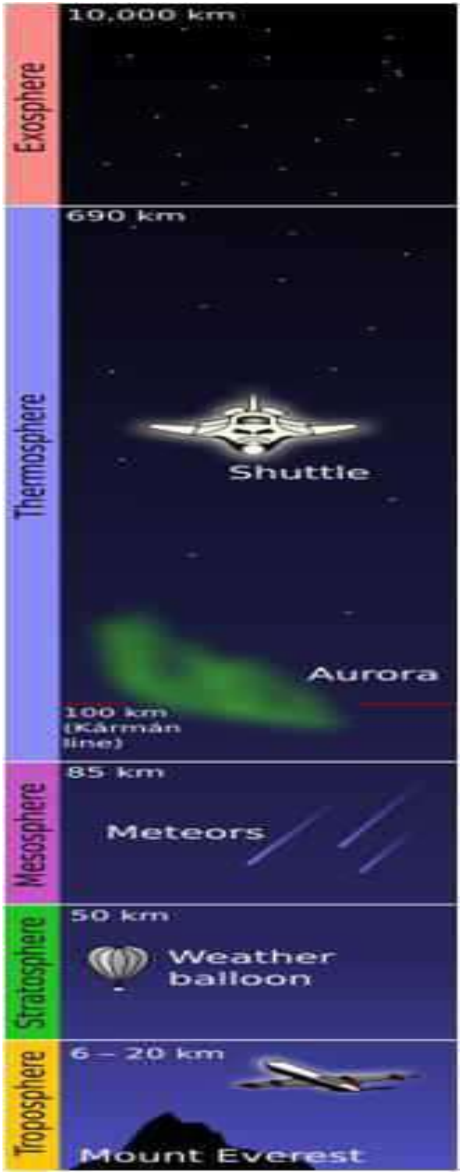
Thermosphere: from 80 – 85 km to 640+ km temperature increasing with height. **Ionosphere**: auroras, long distance radiowave propagation.

Mesosphere: 50 km to 80 to 85 km temperature decreasing with height. Meteors burn up when entering the atmosphere.

Stratosphere: 7 to 17 km range to about 50 km Temperature increases with height. Ozone—few ppm (Mainly 15 to 35 km)

Troposphere: Surface to between 7 km at the poles and 17 km at equator. Weather variations , vertical mixing





http://www.theozonehole.com/atmosphere.htm

Ecosystem

Ecosystem is a functional unit consisting of living and non-living components[ref].

Abiotic factors[ref]:

- Climatic: temperature, rainfall, snow, light levels, wind, humidity
- Edaphic (Soil) Factors: pH, mineral and organic matter, texture

Biotic Factors[ref]:

- Producers (Autotrophs): green plants; chlorophyll
- Consumers (Heterotrophs) pri., sec., ter. consumers
- Decomposers (Saprotrophs): Bacteria, fungi

Organization of the Ecosystem ref

Individual, Species, Organism: An individual living thing, genetically similar enough to breed and produce live, fertile offspring in nature ref

Population: All members of a individual that live in the same area at the same time ref

Biological Community: All populations living and interacting in an area ref

Ecosystem: A biological community and its physical environment ref

Biome: is a set of ecosystems sharing similar characteristics with their abiotic factors adapted to their environments ref

Biosphere: A biosphere is the sum of all the ecosystems established on planet Earth. It is the living (and decaying) component of the earth system ref

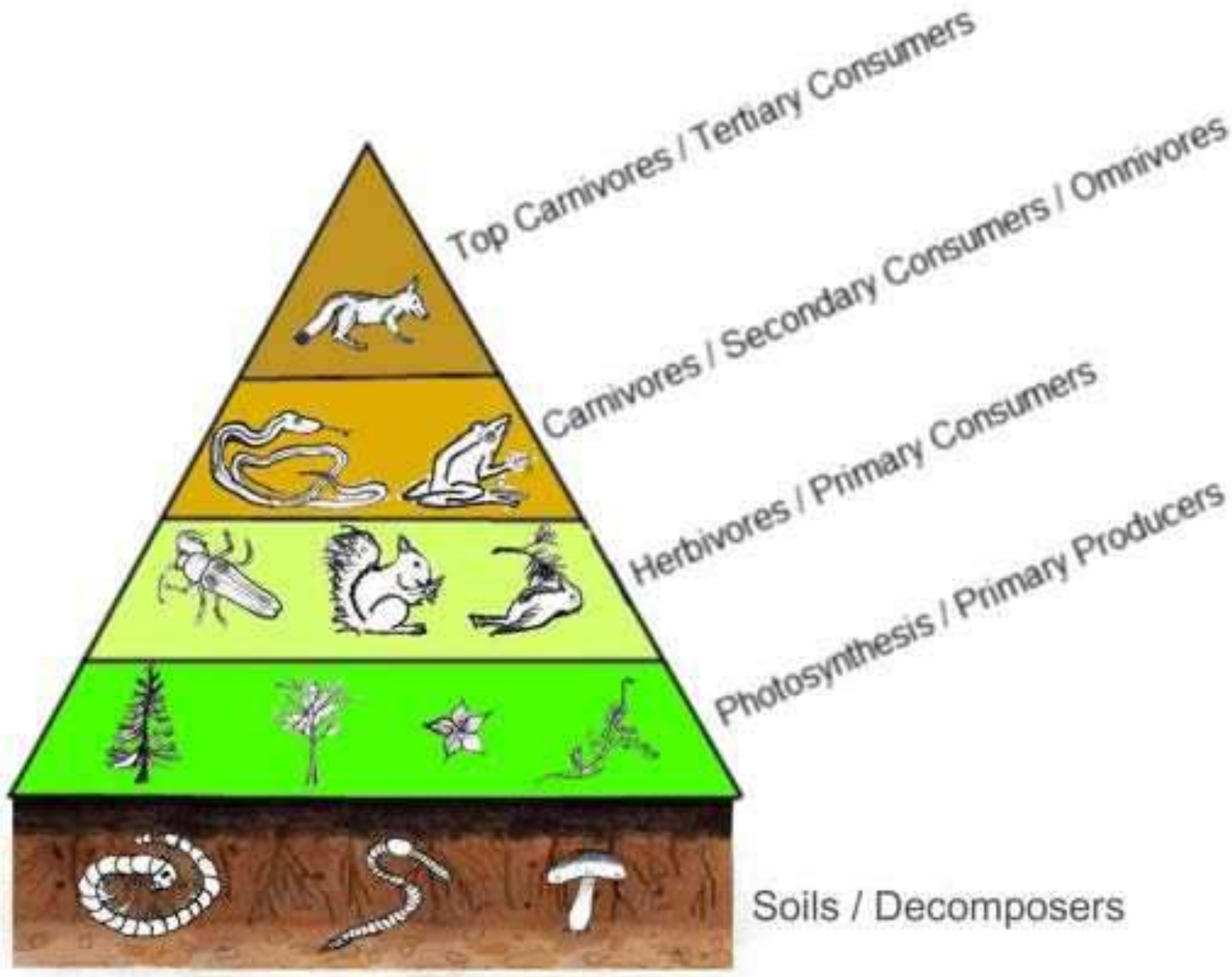
Types of Ecosystems ref

Natural, Artificial

Aquatic Ecosystem: An ecosystem which exists in a body of water is known as an aquatic ecosystem. Majorly two types, **Freshwater ecosystems** and **Marine ecosystems** ref

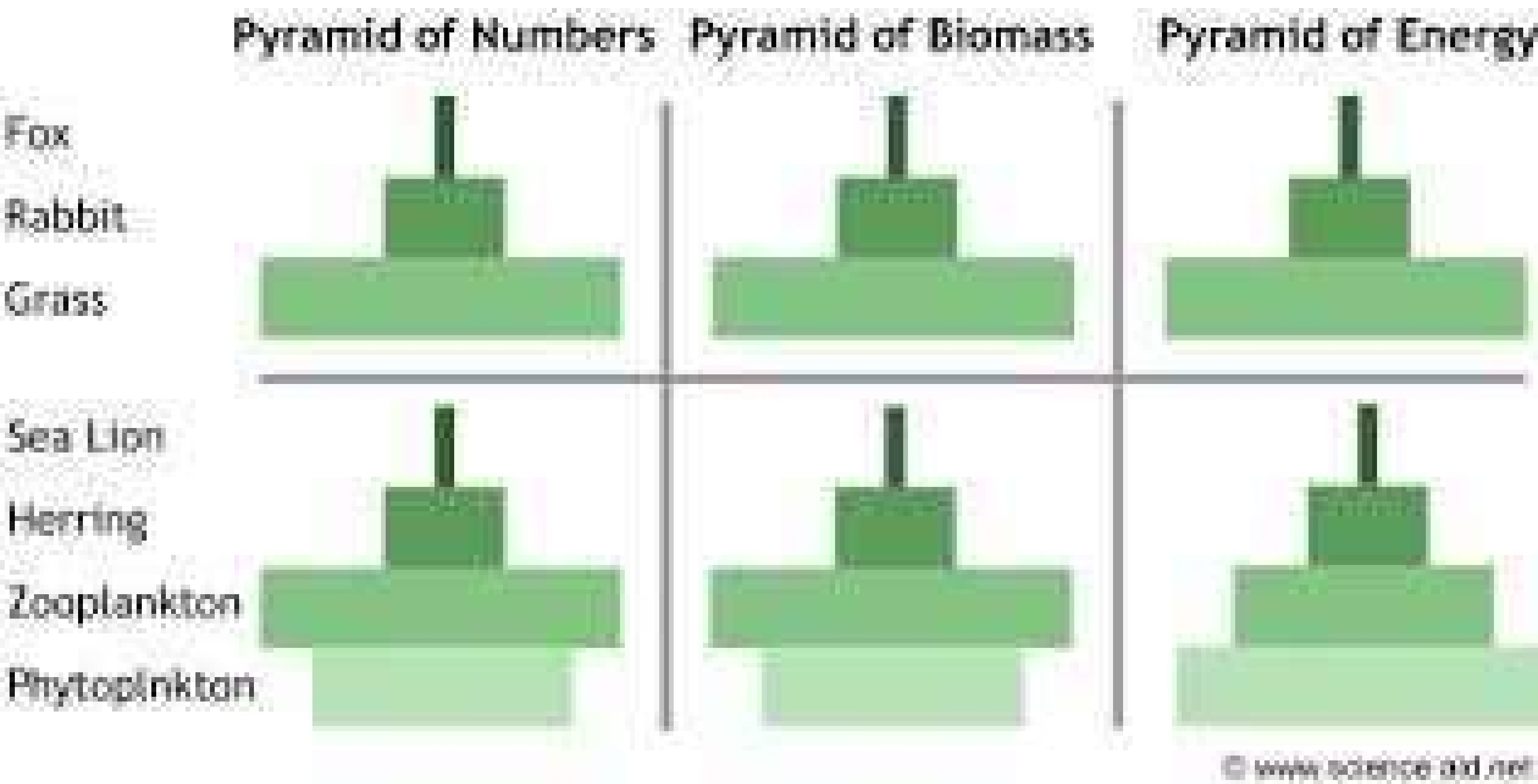
Terrestrial Ecosystem: The ecosystem which is found only on landforms is known as the terrestrial ecosystem. The main types of terrestrial ecosystems are **forest ecosystems, desert ecosystems, grassland ecosystems and mountain ecosystems.** ref

Structure of the Ecosystem - Ecological Pyramids or Trophic Pyramids



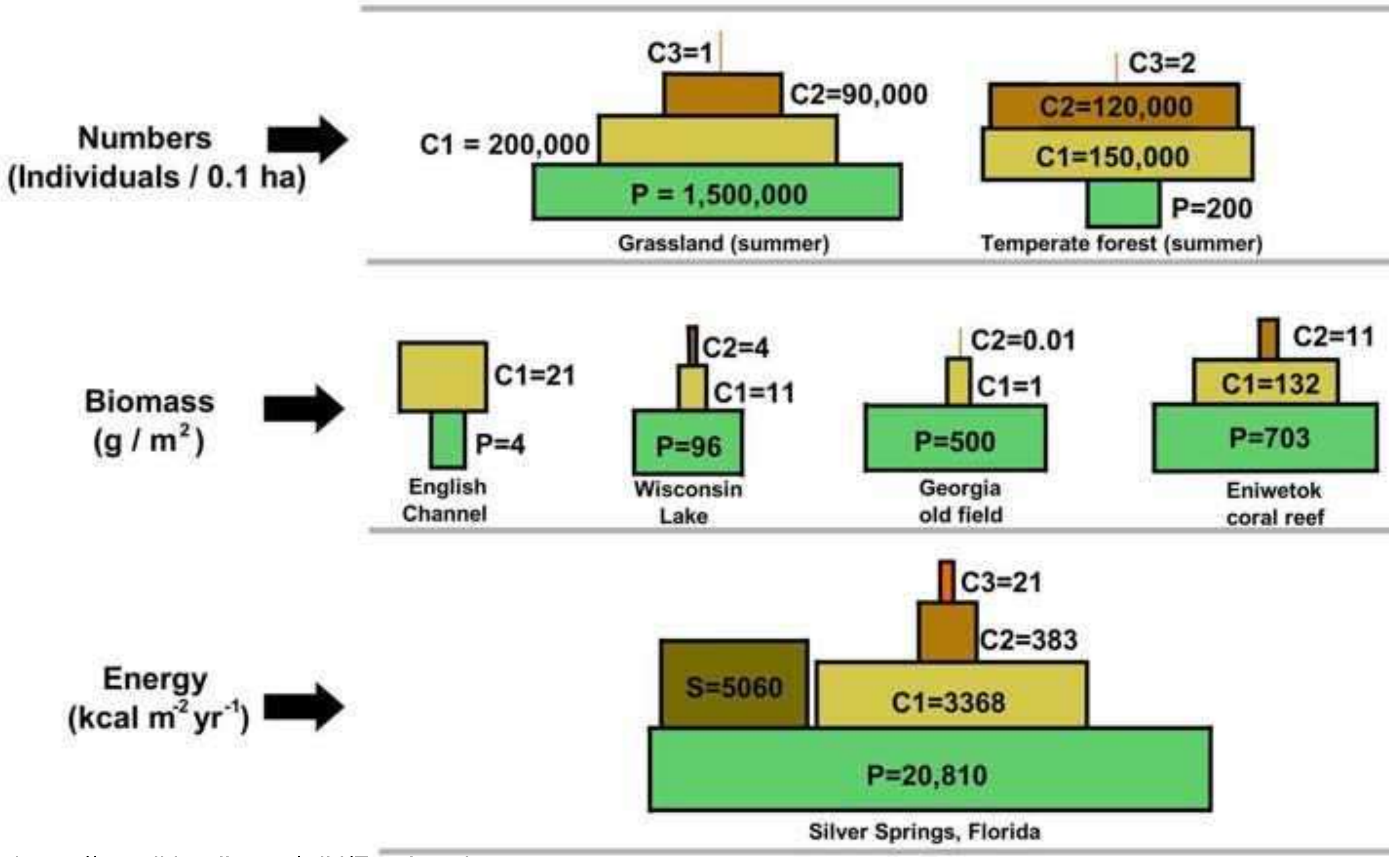
https://en.wikipedia.org/wiki/Food_web

Types of Ecological Pyramids or Trophic Pyramids: Terrestrial Vs Aquatic Ecosystem



http://scienceaid.co.uk/biology/ecology/food.html

Variations in Ecological Pyramid



https://en.wikipedia.org/wiki/Food_web

Ecosystem Functions[ref], [ref]

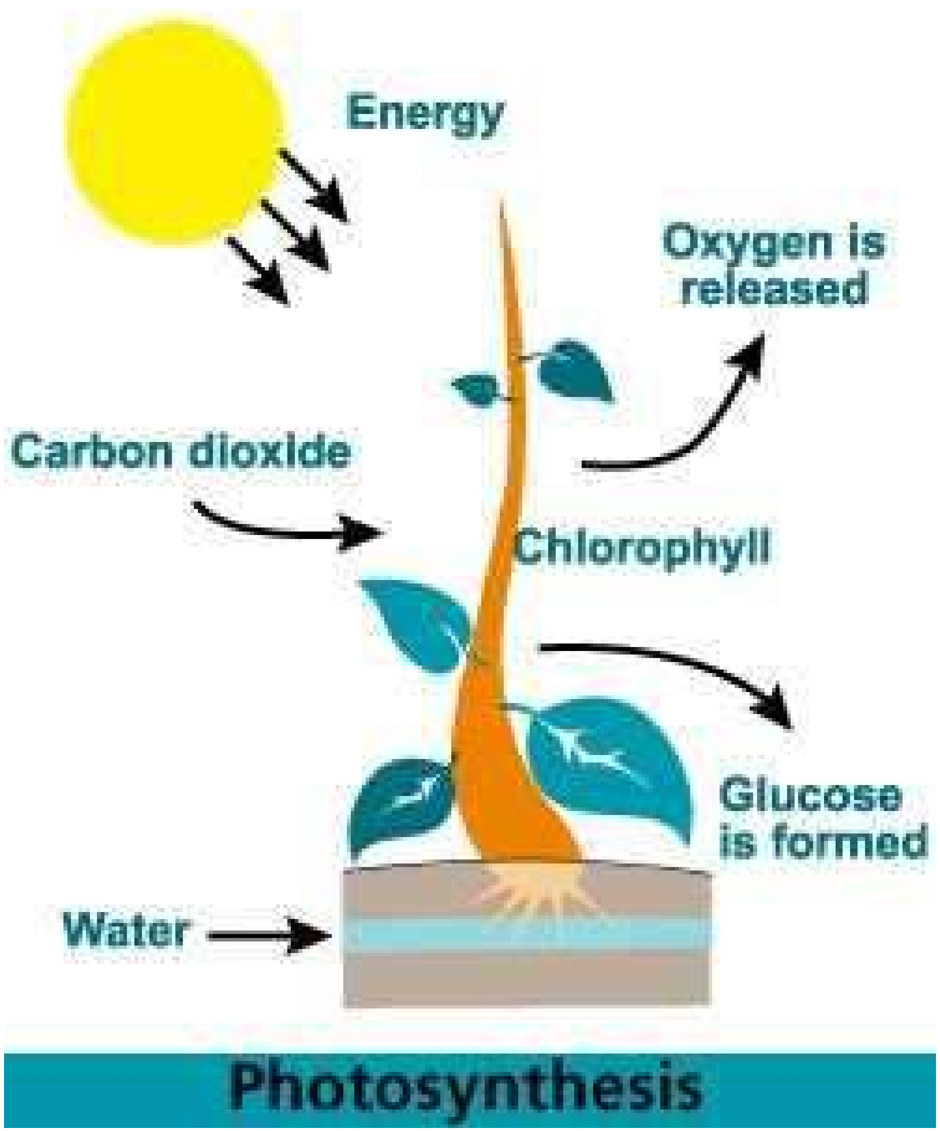
Productivity - Food Production

Energy Flow - Food Chain, Food Web

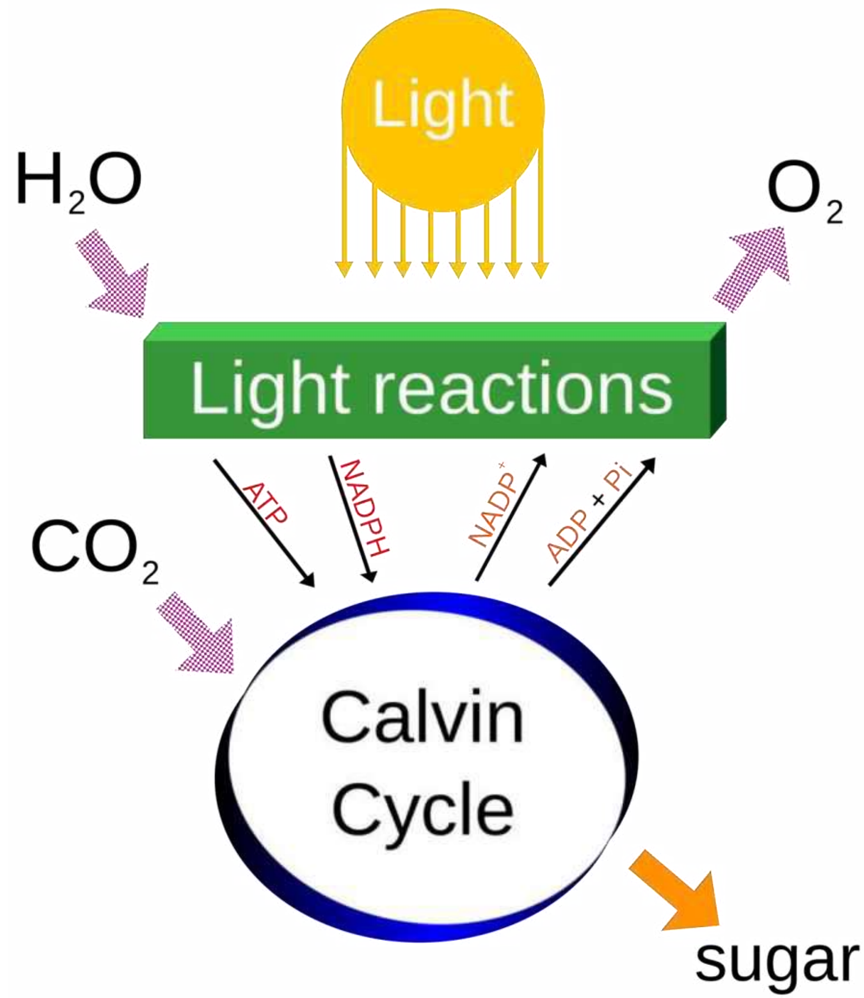
Nutrient recycling - Biogeochemical Cycles

Development and Stabilization - Associations, Adaptations, Succession

Productivity - Food Production

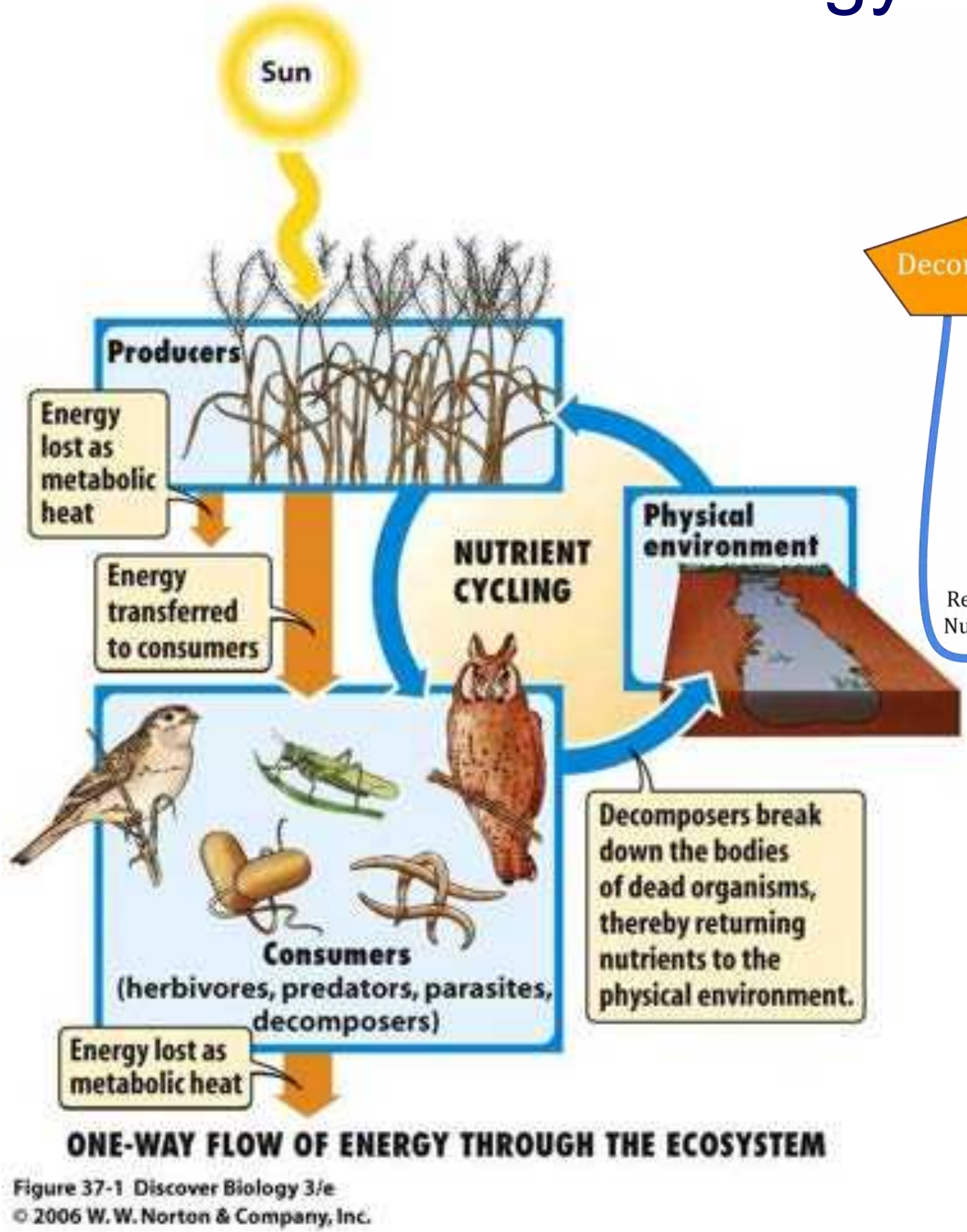


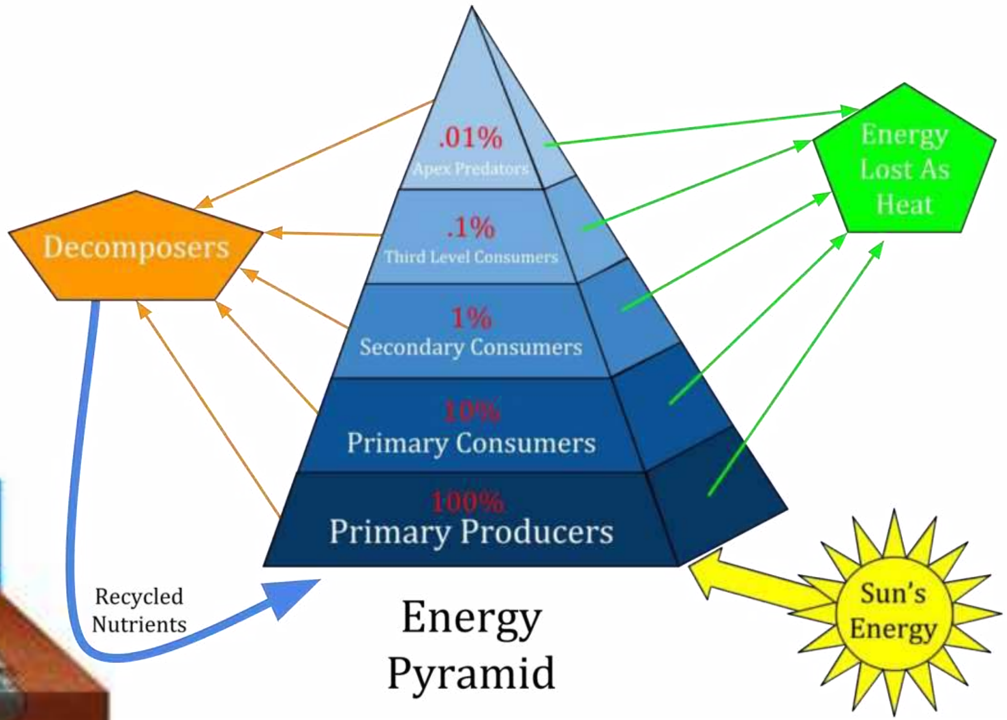
https://upload.wikimedia.org/wikipedia/commons/a/a2/Photosynthesis_Block_diag.gif



https://en.wikipedia.org/wiki/Photosynthesis

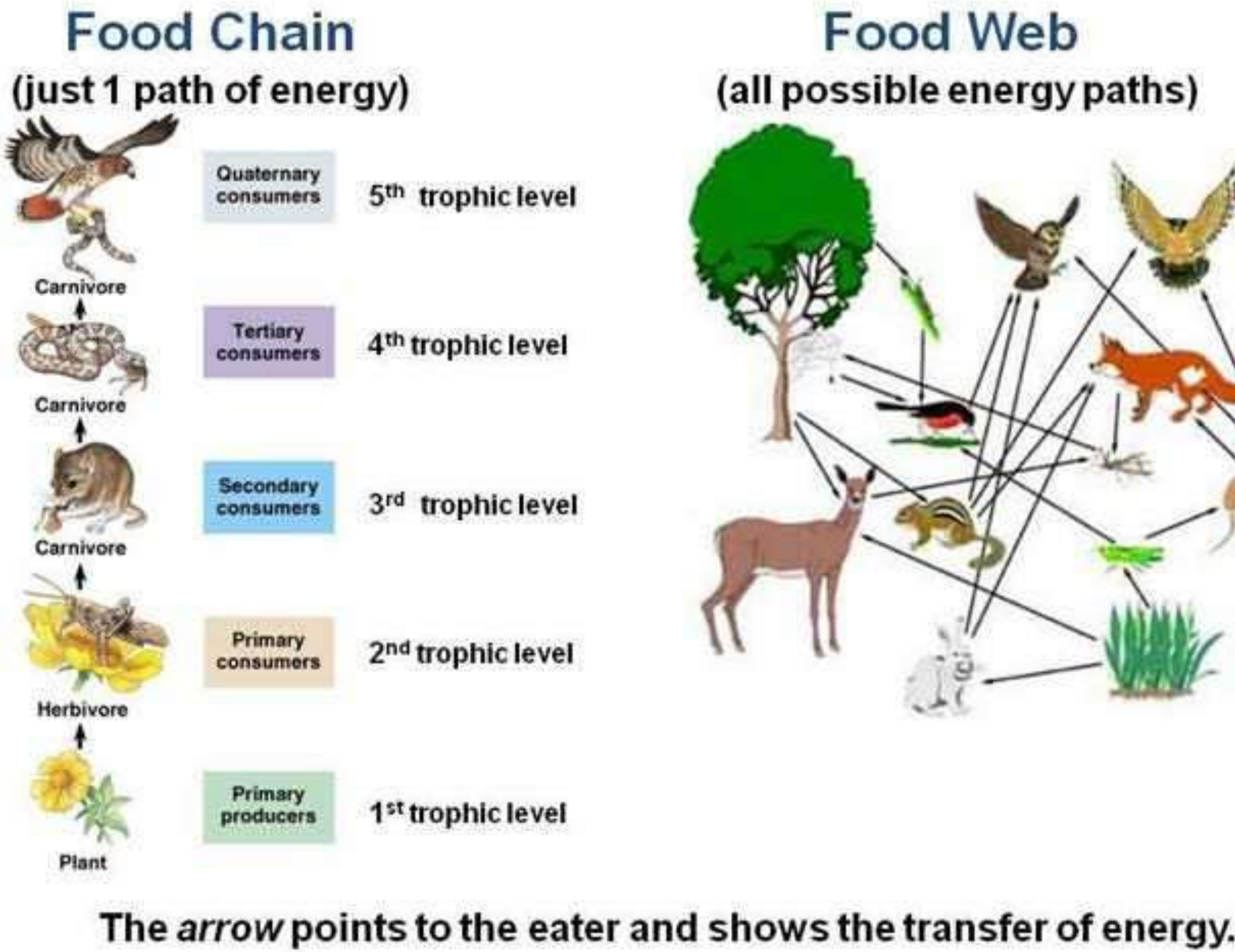
Energy Flow





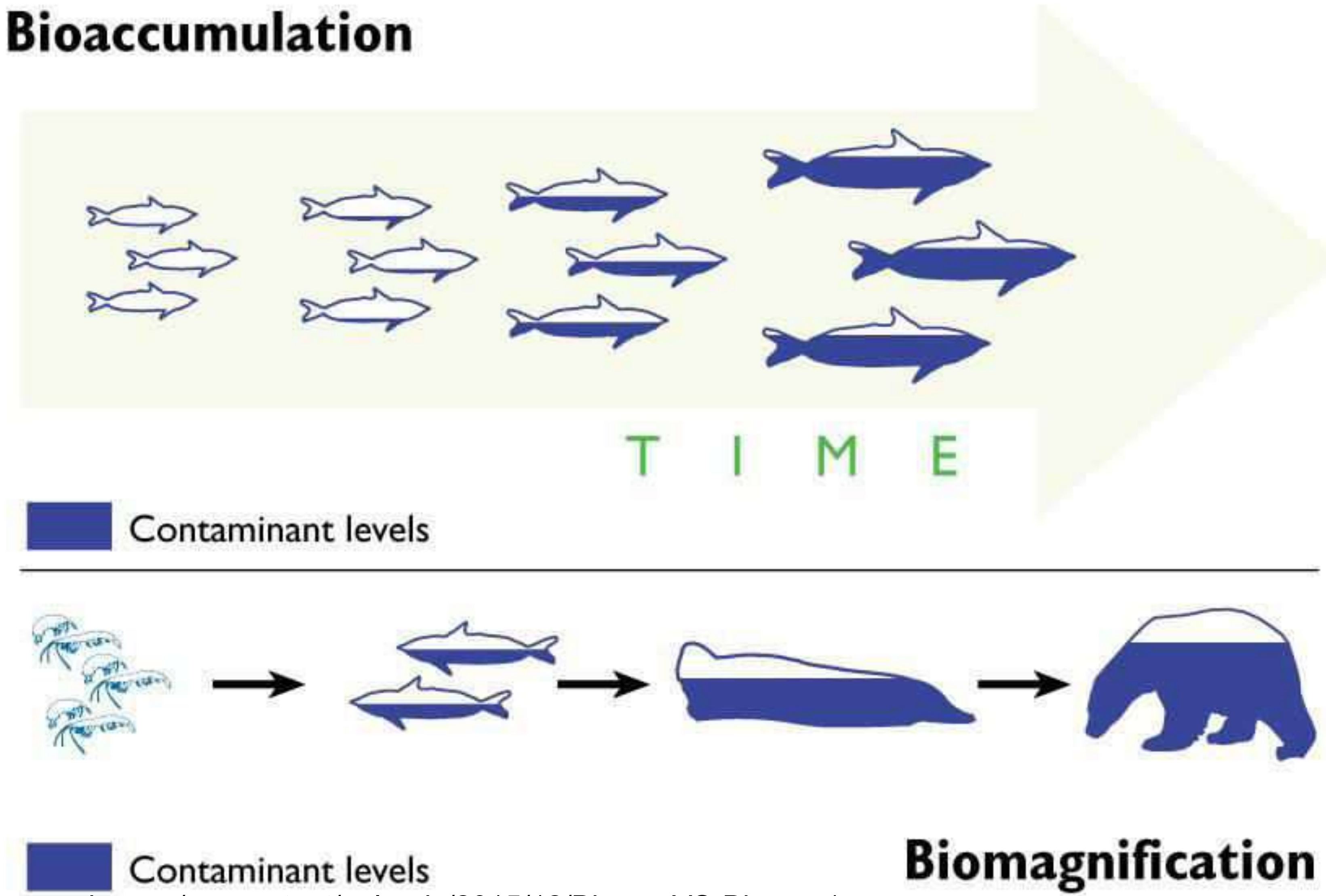
https://upload.wikimedia.org/wikipedia/commons/thumb/3/3a/Ecological_Pyramid.svg/2000px-Ecological_Pyramid.svg.png

https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcRzjOz_0Z0hjtz-ioqM43GrS3M9qDzOnXmtwQPp0BA6TFDfDpFC7g



https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcTsDoYoxXGLYH2SGytHwsD2fyUZEuA232wDRu4pn9AfnbGF-xRh8w

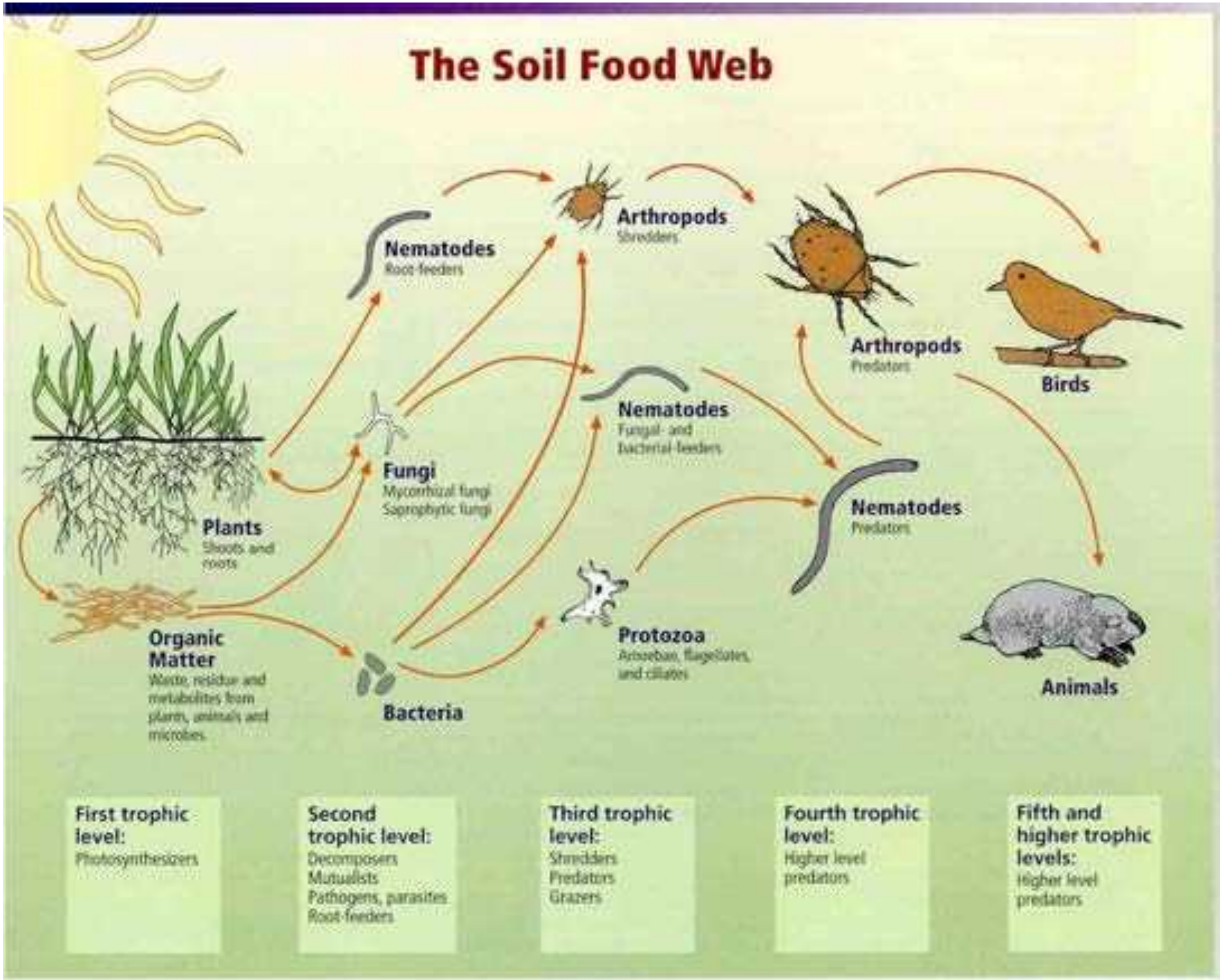
Flow of Chemical and Pollutants through Food Chain



http://iasmania.com/wp-content/uploads/2015/12/Bioacc-VS-Biomag1.png

Detritus Food Chain

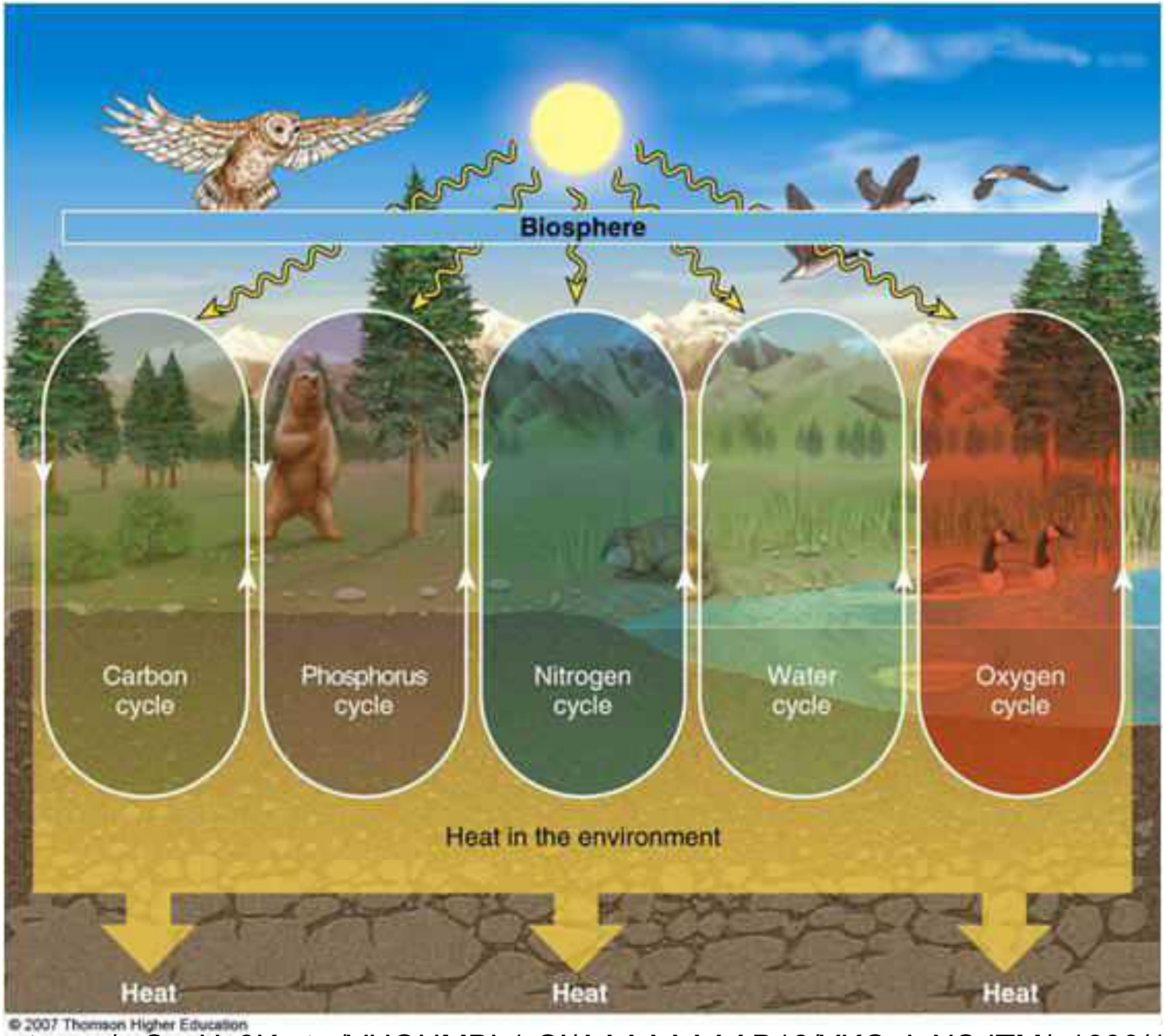
- Less dependent on direct sunlight
- Depends on influx of organic matter from another system
- Generally small
- E.g. Mangrove leaves (detritus)—microorganisms—crabs
- E.g. Caves: bat colonies—guano—organisms (salamanders)
- E.g. Ocean floor—dead carcasses—organisms feeding on it.



Relationships between soil food web, plants, organic matter, and birds and mammals
Image courtesy of USDA Natural Resources Conservation Service
http://soils.usda.gov/sqi/soil_quality/soil_biology/soil_food_web.html.

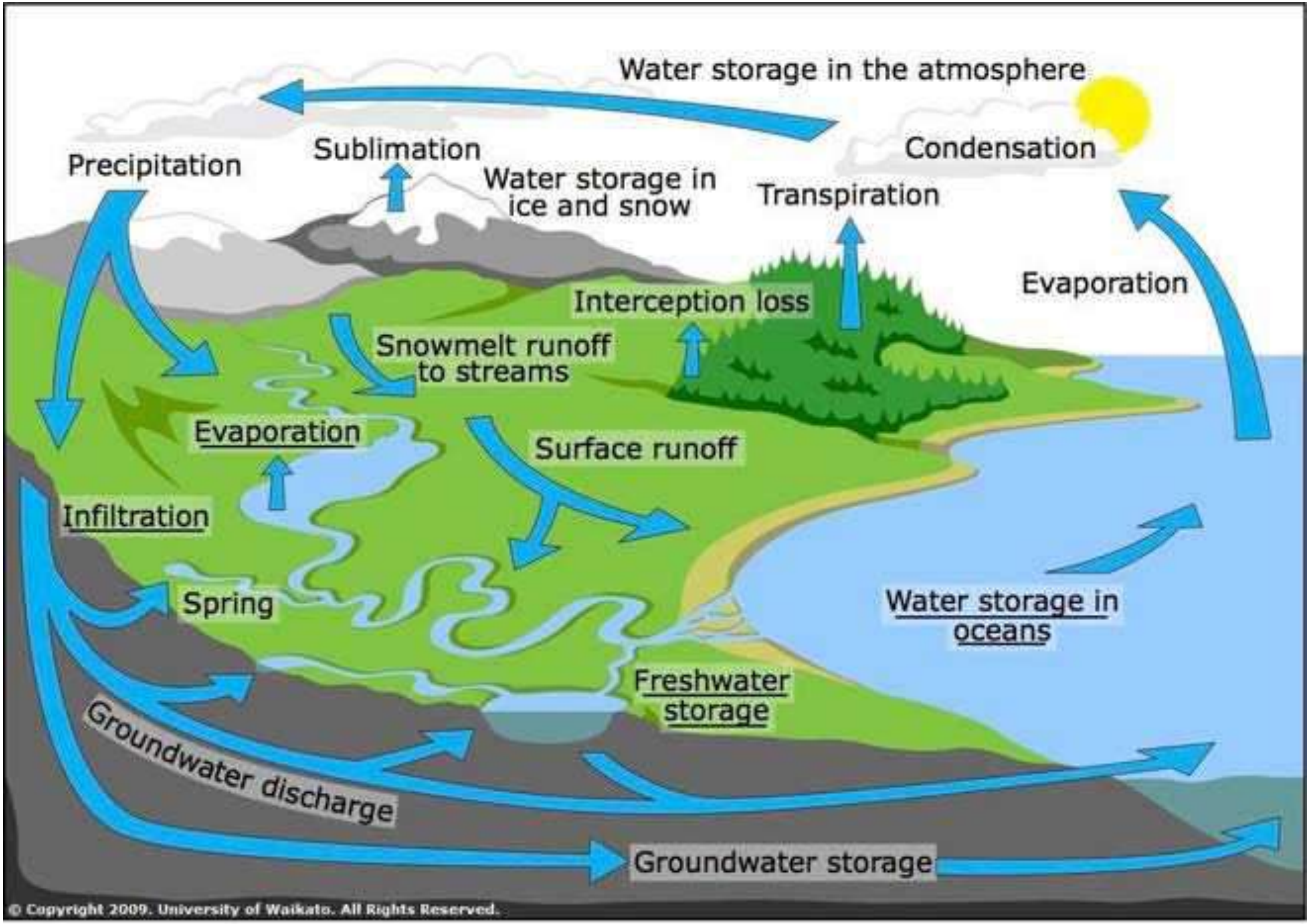
https://en.wikipedia.org/wiki/Food_web

Nutrient recycling - Biogeochemical Cycles



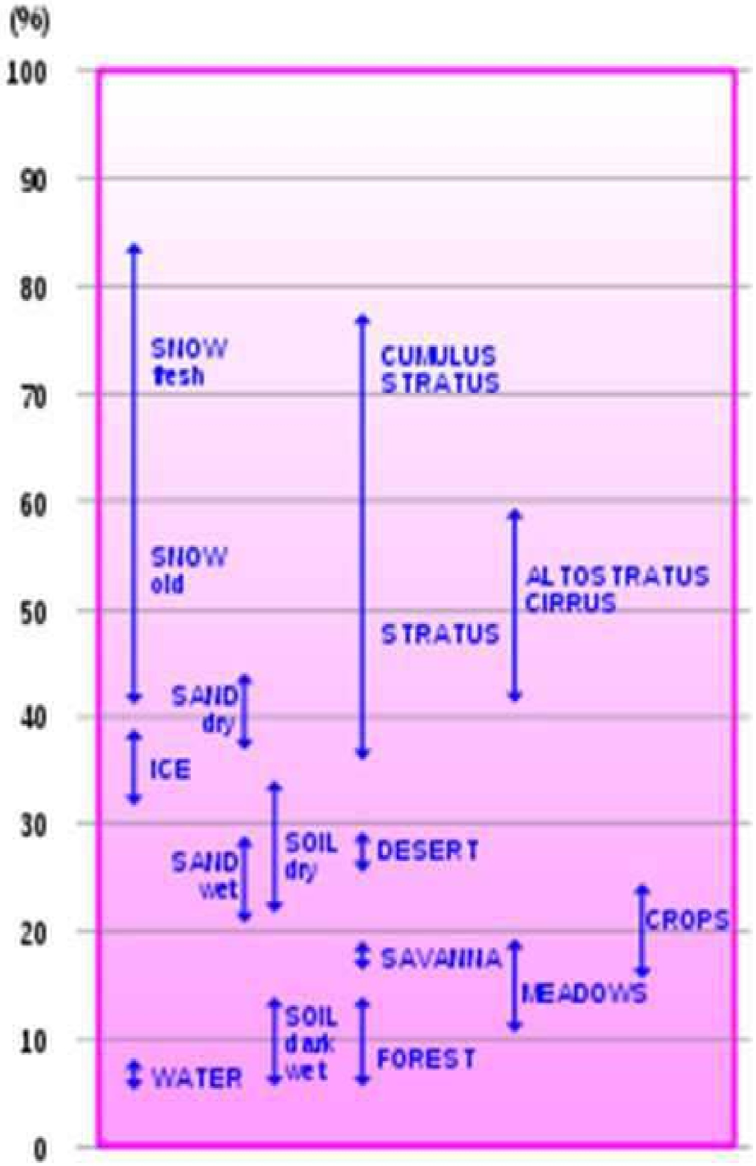
http://1.bp.blogspot.com/-sSscHv8Kmtw/VUQHMBL1rSI/AAAAAAAAB18/YKOplqNSdTM/s1600/1A%2B-%2BBiogeochemical%2BCycle%2BComponents.jpg

Hydrological Cycle



Hydrological Cycle & Earth's Albedo

- Evaporation—cloud formation
- Increased albedo or *reflection coefficient* is a measure of the 'whiteness' of the earth when viewed through space.
- Greater the albedo→lower is the solar radiation absorbed by the earth→lower is the temperature of the globe (Greater cooling).



https://upload.wikimedia.org/wikipedia/commons/thumb/1/18/Albedo-e_hg.svg/549px-Albedo-e_hg.svg.png

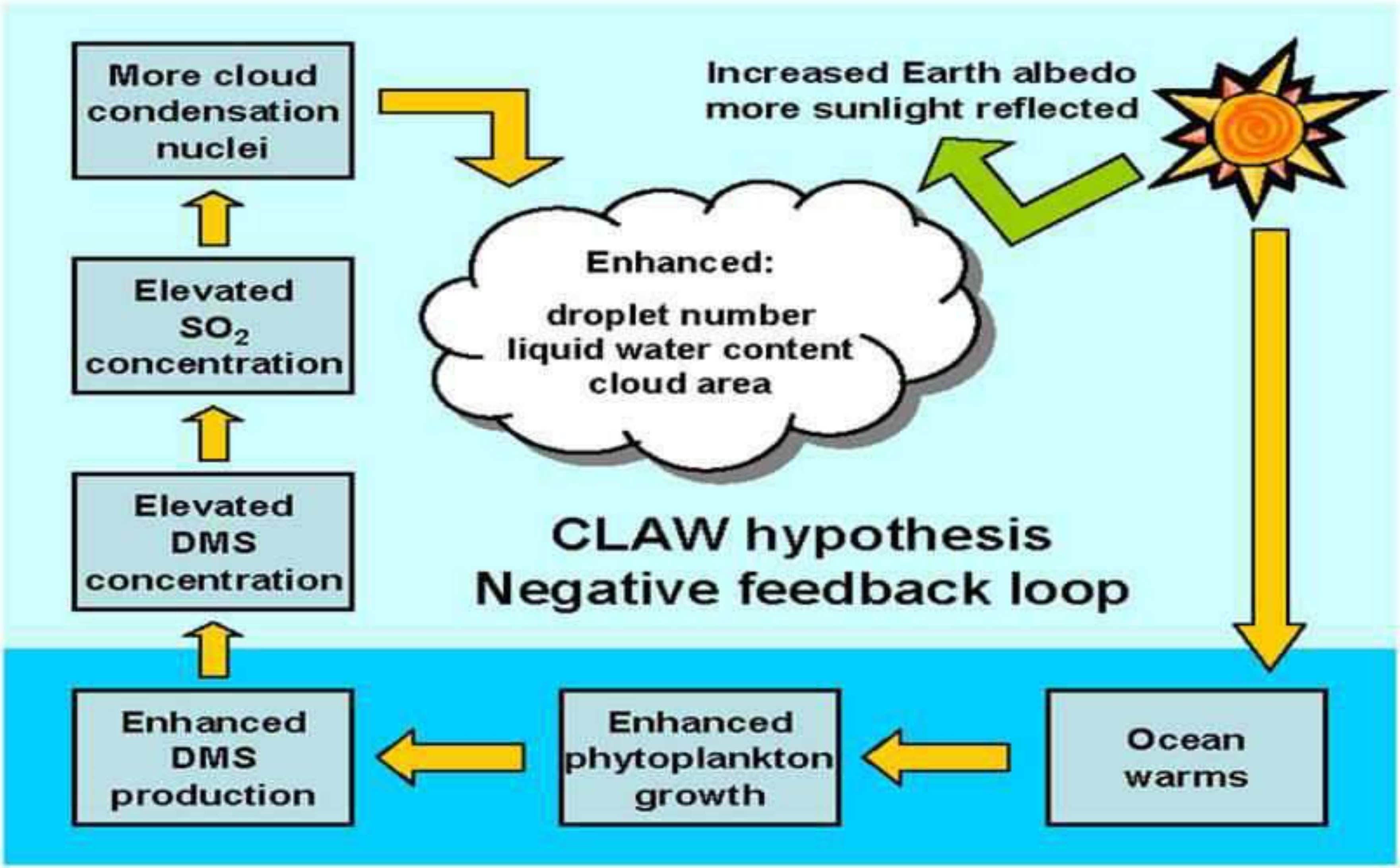
Albedo and Tree Cover

- Trees tend to have a low albedo
  - Deciduous trees: 0.15-0.18 (15-18%)
  - Coniferous trees 0.09-0.15 (9-15%)
- Hence, removing forests → increases albedo →localized climate cooling.
- However, trees also provide local evaporative cooling and carbon sequestration; loss of trees reduces these cooling effects.
- Cloud feedbacks and snow cover further complicate the issue.
- Studies of new forests indicate: (III-ECE-A)
  - A net cooling effect in tropical and mid-latitude areas
  - A net neutral or slightly warming effect in high latitudes (e.g. Siberia)

- Betts, Richard A. (2000). "Offset of the potential carbon sink from boreal forestation by decreases in surface albedo". *Nature* **408** (6809): 187–190. doi:10.1038/35041545.PMID 11089969.

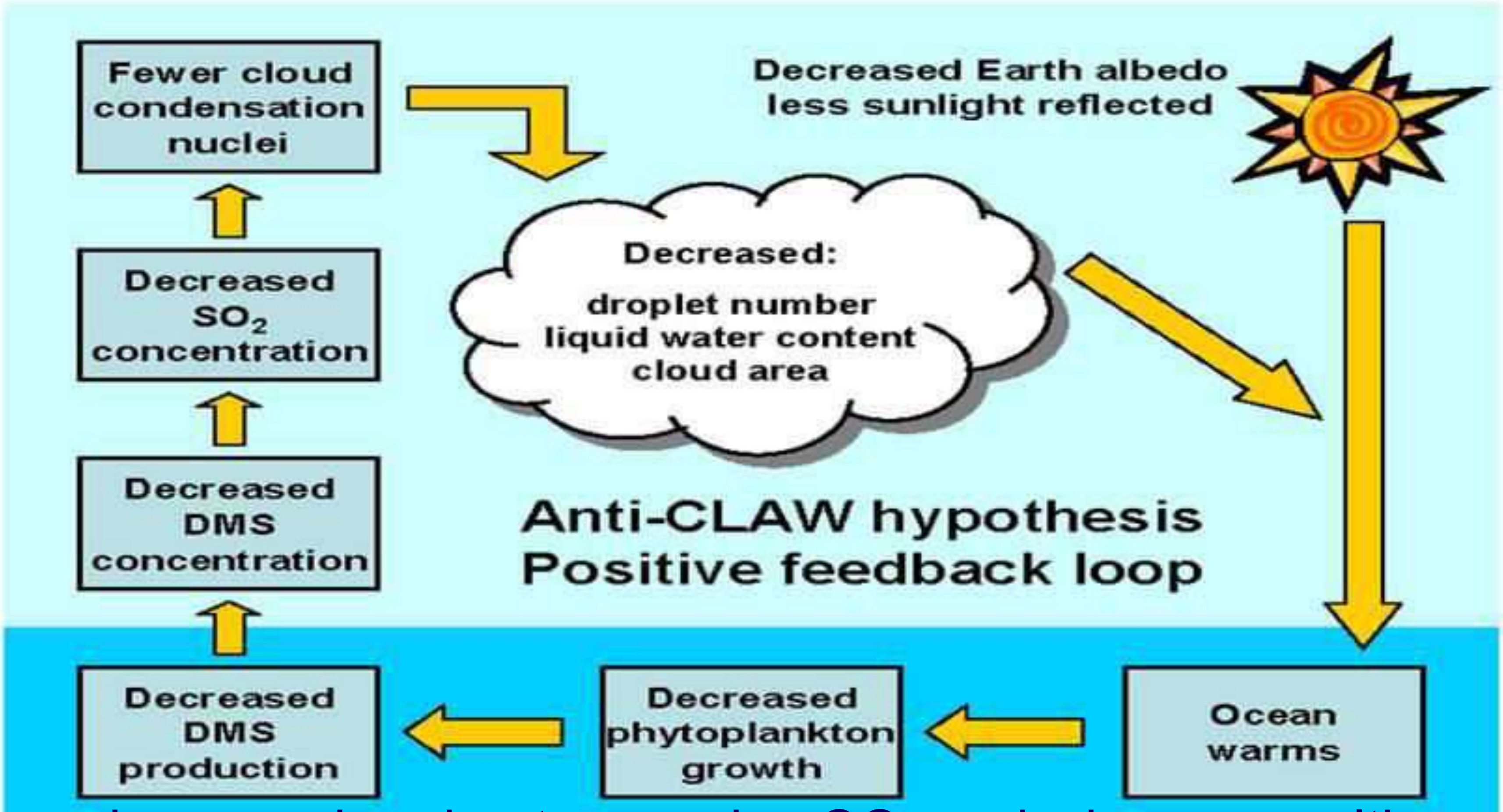
Phytoplankton, Clouds, Albedo

- Phytoplankton produce dimethylsulfoniopropionate (DMSP)
- Converted to Dimethyl sulfide (DMS) in ocean
- Escapes to atmosphere, oxidizes to SO_2 and nucleates clouds.
- This is an example of how the biosphere (plankton) regulates the hydrosphere (global precipitation), earth’s albedo and global temperature.
- **CLAW Hypothesis:** negative feedback; regulation of global temperature.
- **Anti-CLAW Hypothesis:** positive feedback; escalation of global warming.



Mild warming due to CO_2 emissions → warmer oceans→ more phytoplankton → more DMS → More clouds → cooling (negative feedback; regulation)

https://upload.wikimedia.org/wikipedia/en/thumb/f/f5/CLAW_hypothesis_graphic_1_AYool.png/598px-CLAW_hypothesis_graphic_1_AYool.png



Excessive warming due to massive CO_2 emissions → melting of ice caps → **Meltwater pouring into the oceans → stalling of thermohaline ocean currents → ocean stratification** → less transport of nutrients from ocean bottom to euphotic zone → less phytoplankton → less DMS → less clouds → more heating (positive feedback; escalation)

https://upload.wikimedia.org/wikipedia/en/c/cc/CLAW_hypothesis_graphic_2_AYool.png

Plants: Significance in Water Cycle

- Taproots go upto 100x deeper than canopy
- Short-circuit pathways for soil water redistribution
- In dry spells, water from below brought to surface, to increase nutrient extraction, photosysnthesis and transpiration.
- In wet spells, promote percolation

Plants: Significance in Water Cycle

- Plants pump huge quantities of water from soil to air.
  - 100s to 1000s L/day
  - Regulate T and humidity. In a clearing in Nigeria, soil T upto 5°C higher; humidity reduced by 50% compared to adjacent forest.
- Evapo-transpiration of trees—nature's pump and cooler
- Drop in Amazon's temperature in June/July is due to transpiration.
- Transpiration: 40% of Amazonian rain is from transpiration
- Afforestation efforts: appropriate types and density.

●/http://www.i-sis.org.uk/LOG4.php

Importance of Rainforests

- 25% of rain never reaches the ground.; wets canopy and evaporates
- 25% of total—runoff
- 50% of total pumped up and transpired by plants.
- 75% of rainwater is returned to the atmosphere; new clouds, new rain,
- Colossal heat pump—energy of six million atom bombs/day; redistributes energy to higher latitudes
- Up to 80% incident solar energy carried by hot, humid air;
  - rises rapidly and develops into thunder clouds that simultaneously
  - ater areas further downwind
  - releases latent heat

Importance of Rainforests

- Absorb 2 billion tonnes of CO_2/yr; about 20-30% of fossil C emissions
- Destruction of the Amazon:
  - May stall the heat pump
  - Accelerate drought and desertification (positive feedback)
  - Loss of CO_2 sink; accelerate global warming.
  - Reforestation cannot replace natural stands. Loss of soil carbon.

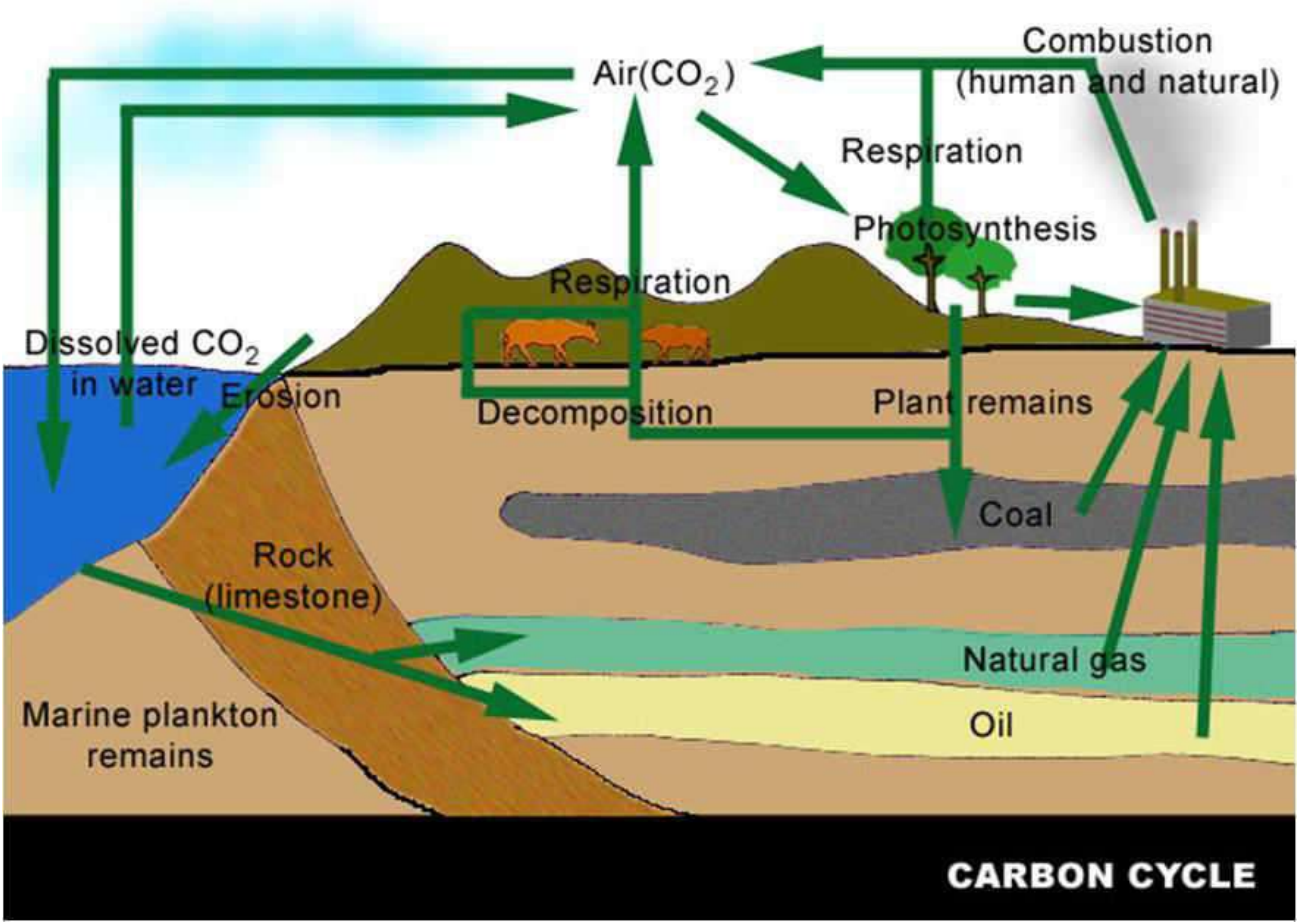
Sources:
Prof. Eneas Salati from the University of São Paulo, Piracicaba – Brasil http://www.fgaia.org.br/texts/e-rainforests.html
http://www.hydrogen.co.uk/h2_now/journal/articles/1_global_warming.htm
http://www.hydrogen.co.uk/h2_now/journal/articles/2_global_warming.htm
http://www.greendiary.com/entry/increasing-global-warming-decreases-forests-co2-absorption-capacity
http://www.i-sis.org.uk/LOG4.php

Human impacts on hydrologic cycle

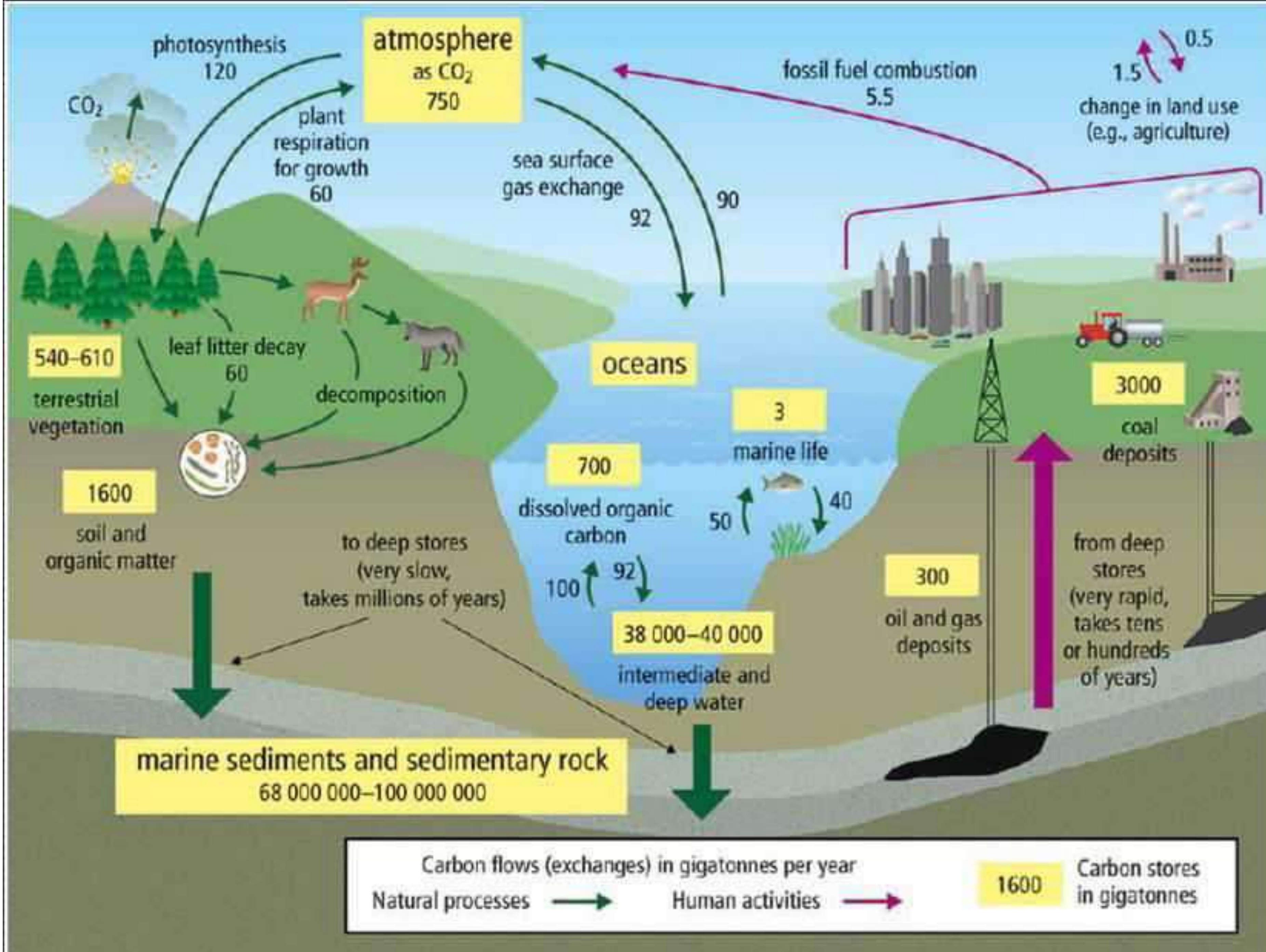
- Damming rivers increases evaporation and infiltration
- Altering the surface and vegetation increases runoff and erosion
- Spreading water on agricultural fields depletes rivers, lakes and streams
- Removing forests and vegetation reduces transpiration and lowers water tables
- Emitting pollutants changes the nature of precipitation
- The most threatening impact is overdrawing groundwater for drinking, irrigation, and industrial use

Availability of Carbon

- Earth's C content = 0.19% (0.032% in lithosphere)
- Atmospheric CO_2 is the main utilizable reservoir
- 18% in biomass
- Main reservoirs air, rocks (carbonates), oceans.



http://image.slidesharecdn.com/biogeochemicalcycles-120914165417-phpapp01/95/biogeochemical-cycles-6-728.jpg?cb=1347641775


atmosphere
as CO_2
750
photosynthesis
120
CO_2
plant
respiration
for growth
60
sea surface
gas exchange
92
90
fossil fuel combustion
5.5
1.5
0.5
change in land use
(e.g., agriculture)
540–610
terrestrial
vegetation
leaf litter decay
60
decomposition
oceans
3
marine life
3000
coal
deposits
1600
soil and
organic matter
700
dissolved organic
carbon
50
40
100
92
to deep stores
(very slow,
takes millions of years)
38 000–40 000
intermediate and
deep water
300
oil and gas
deposits
from deep
stores
(very rapid,
takes tens
or hundreds
of years)
marine sediments and sedimentary rock
68 000 000–100 000 000
Carbon flows (exchanges) in gigatonnes per year
Natural processes
Human activities
1600
Carbon stores
in gigatonnes

Potential contributors to climate change

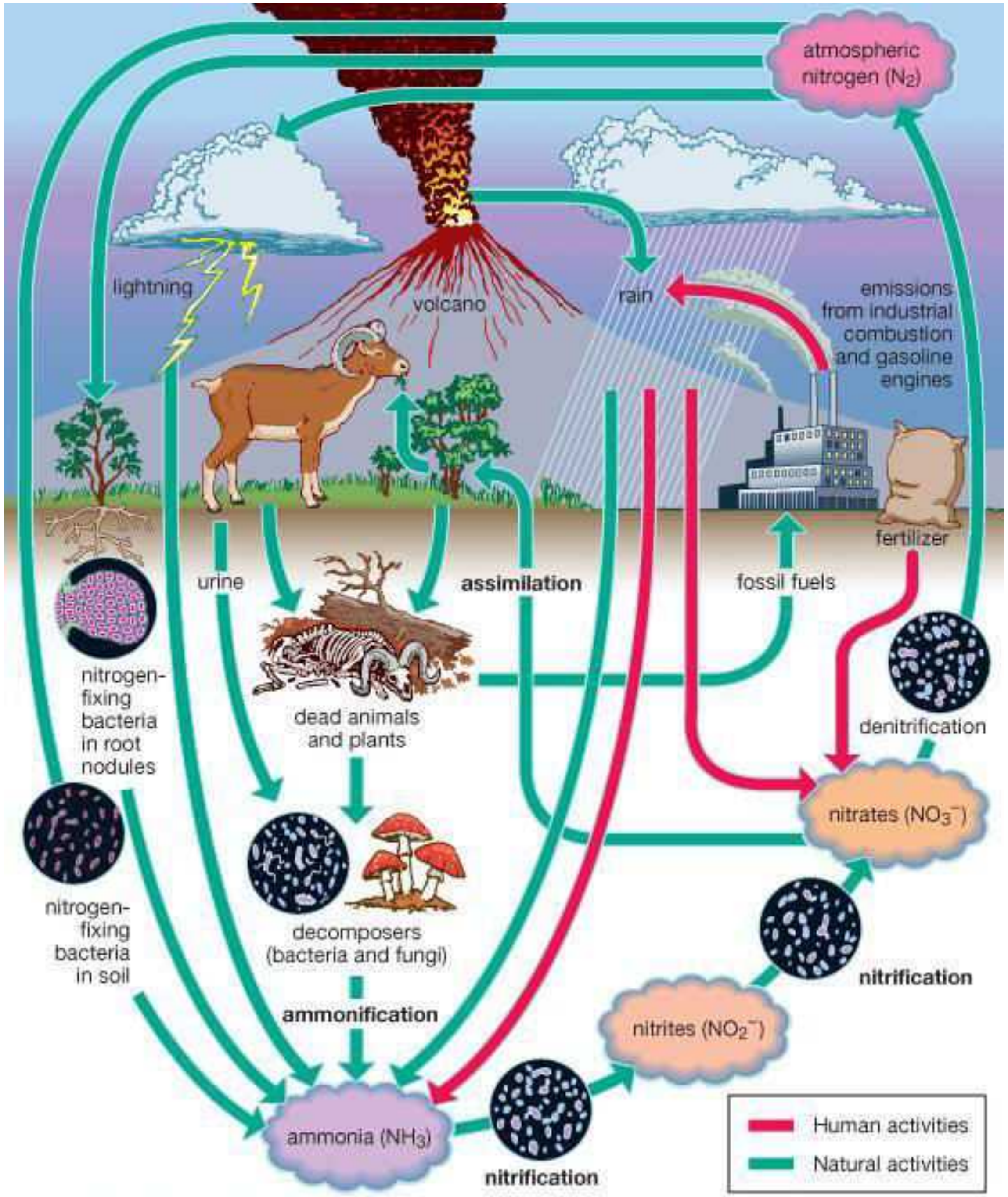
- Complex interactions in the climate puzzle
- Feedback mechanisms
- Some interesting twists
    - Increasing temp. reduces CO_2 solubility (reduced C-sink capacity of the ocean)
    - Ocean Acidification reduces C-sequestration in the form of $CaCO_3$
    - 740ppm CO_2 in water by 2100. Reduction in population of mussels by 25% and oysters by 10%
    - At 1800ppm, shells will dissolve

Human Impacts on Carbon Cycle

- Burning of Fossil fuels
- Deforestation and Poor Agricultural practices
- Increase in atmospheric greenhouse gasses such as CO_2, methane, SO_X, NO_X, etc. leads to Greenhouse effect, global warming and climate change.

Nitrogen Reservoir

- N is an essential component of proteins, nucleic acids and other cellular constituents.
- **Reservoirs –** 79% of the atmosphere is N_2 gas.
- The N≡N triple bond is relatively difficult to break, requires special conditions. As a result most ecosystems are N-limited.
- N_2 dissolves in water, cycles through air, water and living tissue.


atmospheric nitrogen (N_2)
lightning
volcano
rain
emissions from industrial combustion and gasoline engines
urine
assimilation
fossil fuels
fertilizer
nitrogen-fixing bacteria in root nodules
dead animals and plants
denitrification
nitrates (NO_3^-)
nitrogen-fixing bacteria in soil
decomposers (bacteria and fungi)
nitrification
ammonification
nitrites (NO_2^-)
ammonia (NH_3)
nitrification
Human activities
Natural activities

Nitrogen Fixation

- <u>Abiotic:</u> lightning (very high T and P) 10^7 metric tons yr^{-1} ~ 5-8% of total annual N fixation. (weathering of rocks is insignificant)
- <u>Biotic:</u> Nitrogen fixation by microbes, 1.75 $x10^8$ metric tons yr^{-1} (symbiotic bacteria: *azobacter* or *rhizobium*- legumes
- <u>Industrial:</u> The Haber-Bosch process (1909) $5x10^7$ metric tons yr^{-1} – high P & T, Fe catalyst to convert N_2 to $NH_{3;}$& NH_4NO_3
- <u>Combustion Side Effect</u>: $2x10^7$ metric tons $yr^{-1.}$ High T and P oxidizes N_2 to NO_x

Nitrification-Denitrification

- **Nitrification** by chemoautotrophs
  - Bacteria of the genus *Nitrosomonas* oxidize NH_3 to NO_2^-
  - Bacteria of the genus *Nitrobacter* oxidize the nitrites to NO_3^-
- **Denitrication** Anaerobic respiration of NO_3^- to dinitrogen gas by several species of *Pseudomonas*, *Alkaligenes*, and *Bacillus*

Human Impacts on Nitrogen Cycle

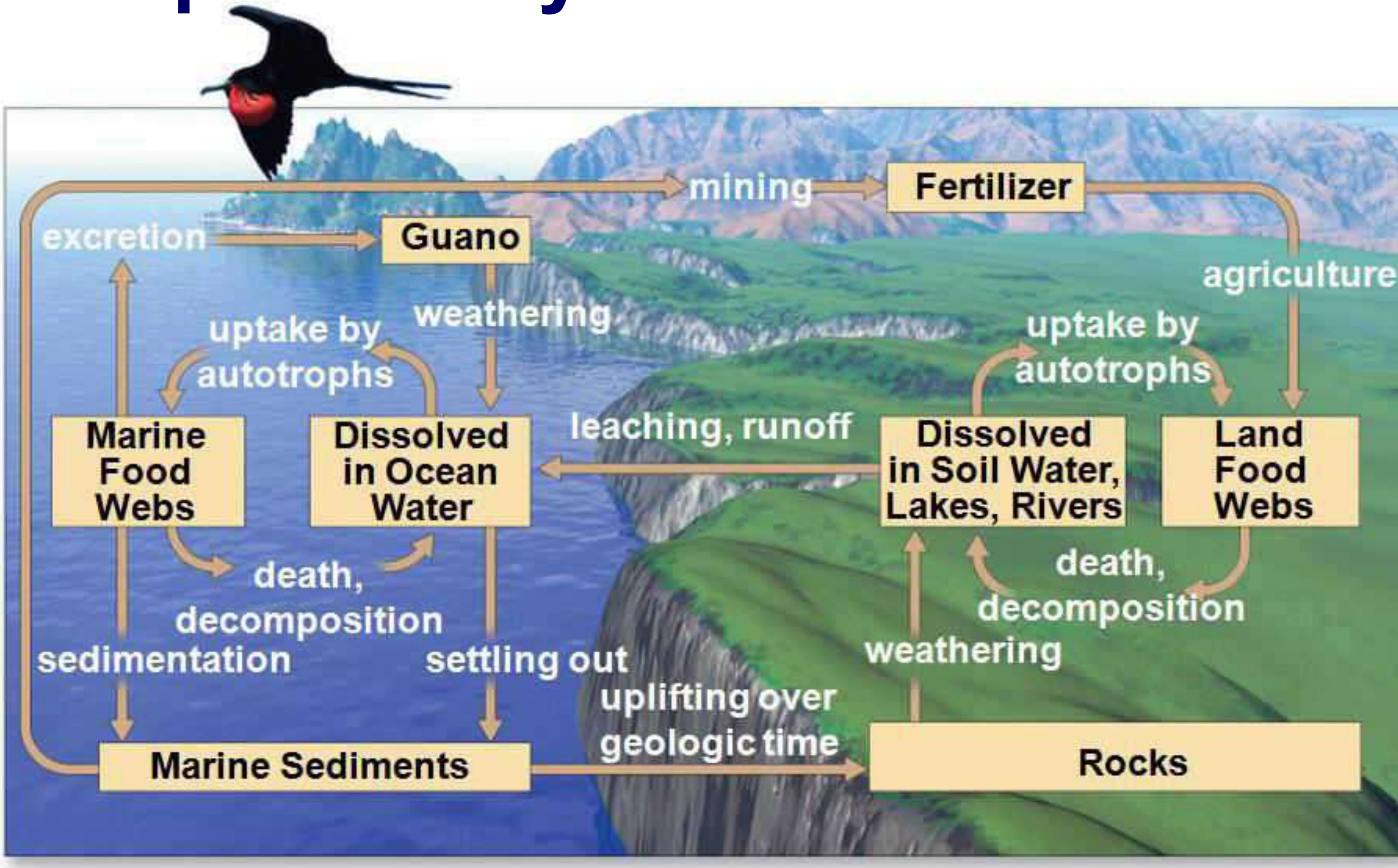
- Burning of Fossil fuels add Nitrogen Oxides (NO_2) and Nitric Acid vapor (HNO_3).
- Nitrous Oxide (N_2O) released by the action of anaerobic bacteria on Livestock waste.
- Nitrogen stored in Soil and Plants released by destruction of forestlands, grassland and wetlands.
- Upset the nitrogen cycle in aquatic ecosystem by adding excess of nitrates to the body
- Harvest nitrogen-rich crops, irrigate crops, wash out nitrogen from topsoils

Fate of N

- **Sources of anthropogenic N loads:** Fertilizers, Legume Crops, Combustion and forest burning, livestock.
- In most terrestrial and freshwater ecosystems N is a limiting nutrient, gets cycled efficiently.
- What happens when plants have enough N (i.e. greater 16:1 N:P ratio)?
- When N saturation of ecosystem occurs, excess N tends to leave the system in the form of nitrate.
- Flushing/erosion – dissolved and particulate matter in streamwater, (DIN, DON, TN, Org N)
- Leaching to groundwater – NO_3^- poor sorption to clays, highly water soluble.

- Selective pressures in terrestrial systems favoring species-poor grasslands and forests
- Nitrate MCL – 10 mg/L …
- Nitric oxide – precursor of acid rain and smog
- Nitrous oxide – long lived greenhouse gas that can trap 200 times as much heat as CO_2

Phosphorus Cycle



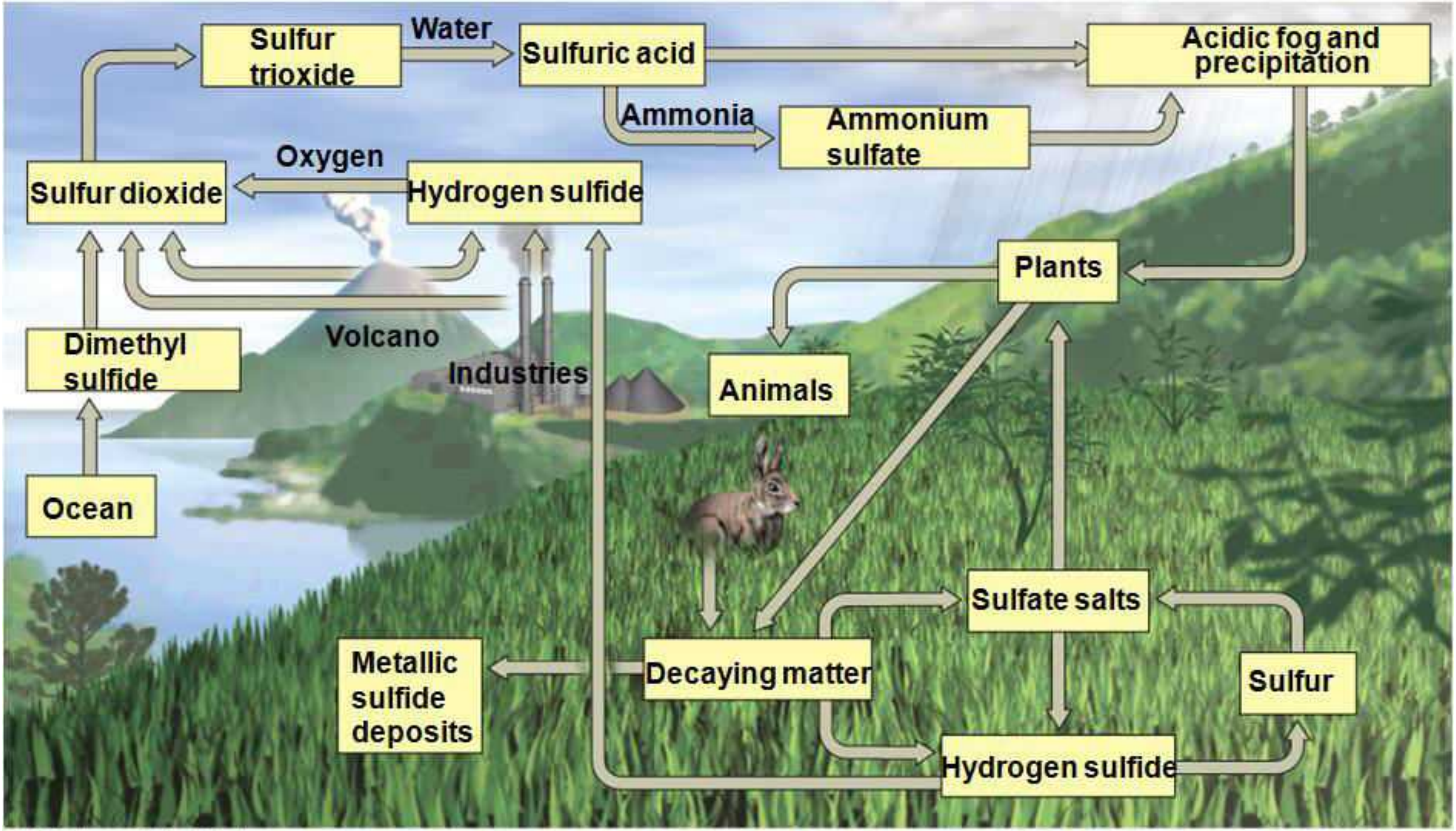
Ref

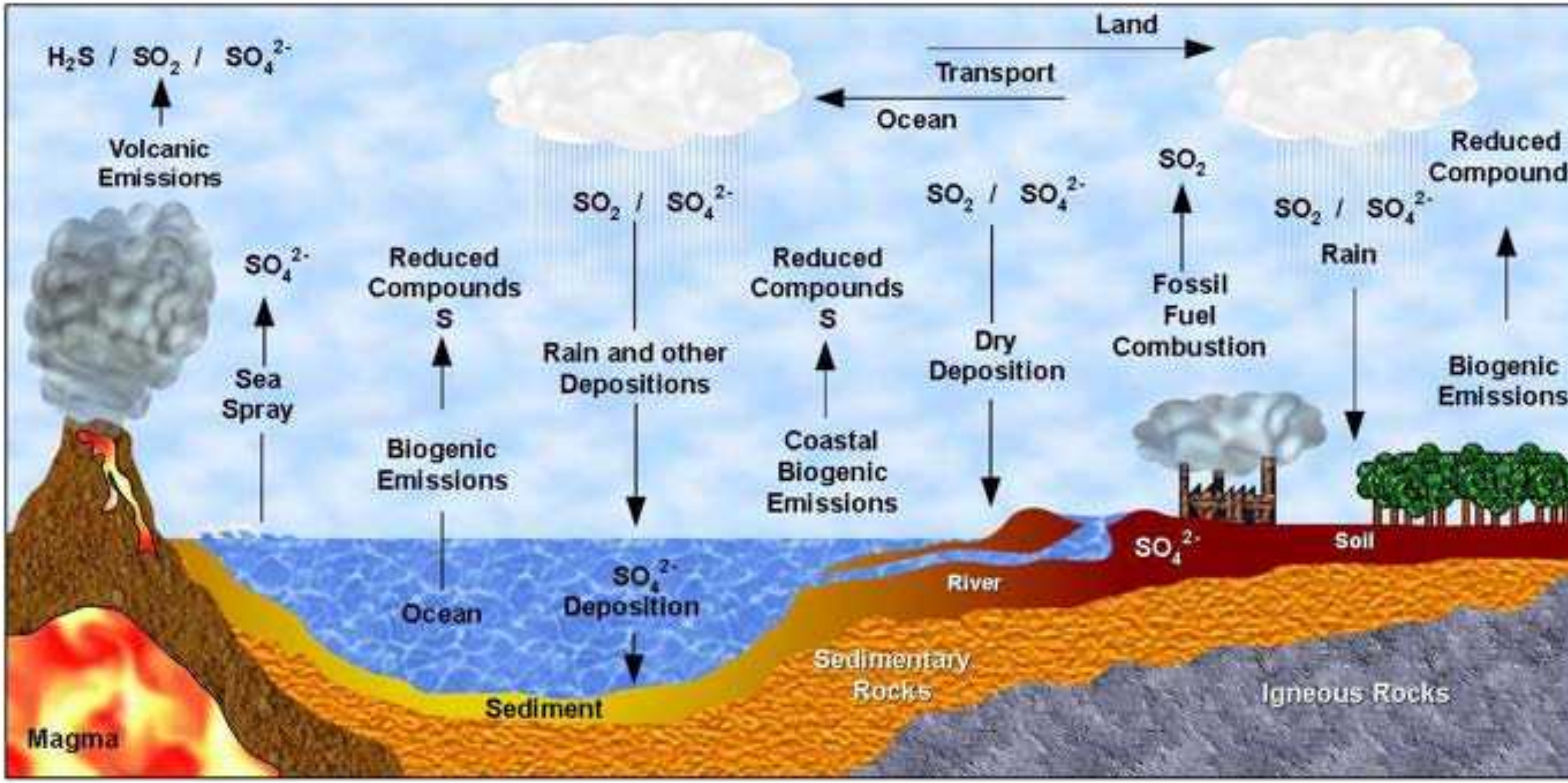
- One of the longest cycles
- Essential nutrient; DNA, ATP, ADP, fat, cell membranes

Human Impacts on Phosphorus Cycle

- P-containing detergents
- Mining phosphate rock
- P-containing fertilizer use
- P in water leads to eutrophication

Sulphur Cycle





H_2S / SO_2 / SO_4^{2-}
Volcanic Emissions
Land
Transport
Ocean
SO_2 / SO_4^{2-}
SO_2 / SO_4^{2-}
SO_2
Reduced Compounds
SO_2 / SO_4^{2-}
SO_4^{2-}
Reduced Compounds S
Rain and other Depositions
Reduced Compounds S
Dry Deposition
Fossil Fuel Combustion
Rain
Biogenic Emissions
Sea Spray
Biogenic Emissions
Coastal Biogenic Emissions
SO_4^{2-}
Soil
River
Ocean
SO_4^{2-} Deposition
Sedimentary Rocks
Igneous Rocks
Sediment
Magma

Human Impacts on Sulfur Cycle

- SO_2 from industry and combustion (e.g. coal, petrol).

- SO_2 from Refine industry convert the Petroleum

to Gasoline Products

- SO_2 from Metallic ore Industries.
- SO_2 from Mining industries - Acid mine drainage

- Self regulation: chemistry of oceans, atmosphere, temperature, living beings
- Earth behaves as if it had a purpose
- Purpose is to nurture life and maintain life-friendly conditions.
- This perspective brings a new awareness that can be the foundation of all future development
- It will enable the further evolution of mankind

Ecosystem Services ref

Ecosystem ‘services’ are provided free-of-charge as a gift of nature.

- purification of air and water
- regulation of rainwater run-off and drought
- waste assimilation and detoxification
- soil formation and maintenance
- control of pests and disease
- plant pollination, seed dispersal and nutrient cycling

- maintaining biodiversity for agriculture, pharmaceutical research and development and other industrial processes
- protection from harmful ultraviolet radiation
- climate stabilization (for example, though carbon sequestration)
- moderating extremes of temperature, wind, and waves.

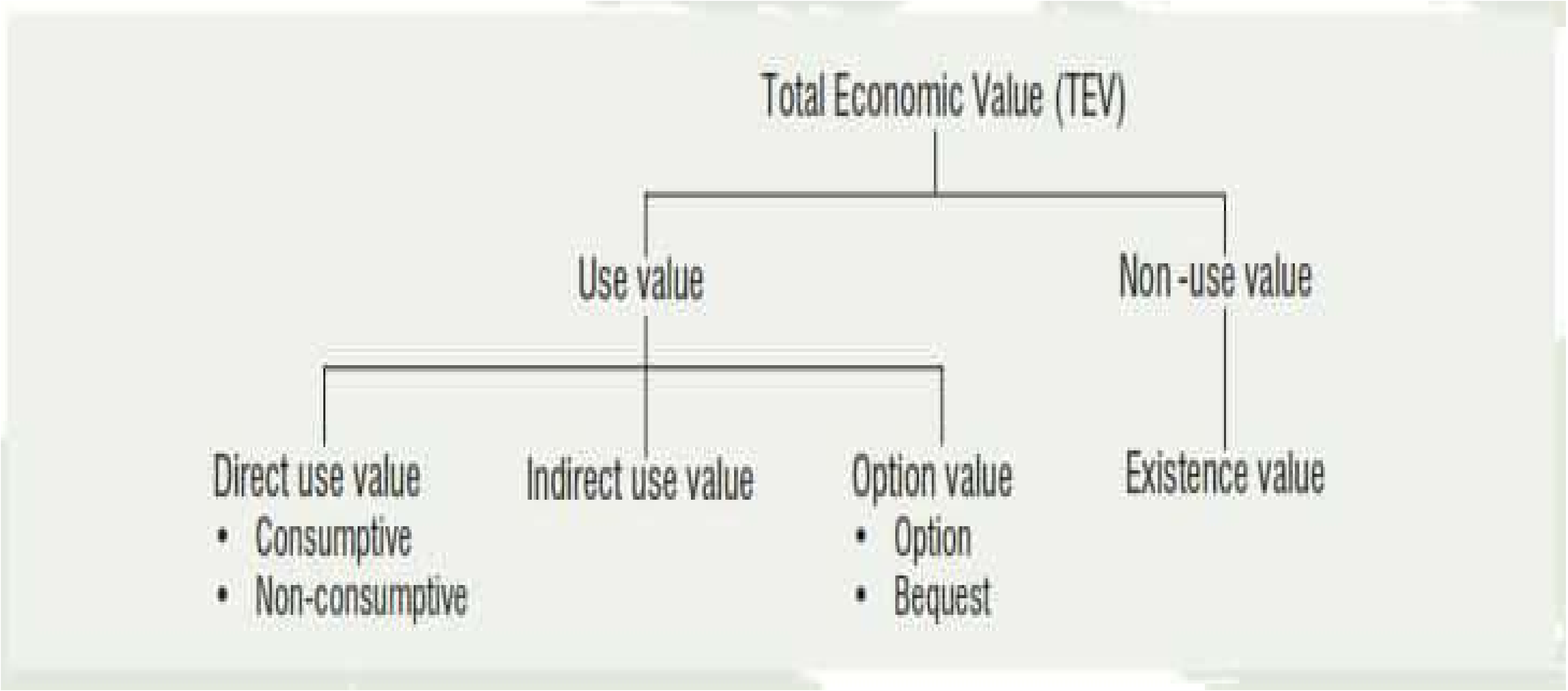
Major Ecosystem Types and Services ref

Ecosystem service	*Ecosystem*									
	Cultivated	*Dryland*	*Forest*	*Urban*	*Inland Water*	*Coastal*	*Marine*	*Polar*	*Mountain*	*Island*
Freshwater			•		•	•		•	•	
Food	•	•	•	•	•	•	•	•	•	•
Timber, fuel, and fiber	•		•			•				
Novel products	•	•	•		•		•			
Biodiversity regulation	•	•	•	•	•	•	•	•	•	•
Nutrient cycling	•	•	•		•	•	•			
Air quality and climate	•	•	•	•	•	•	•	•	•	•
Human health		•	•	•	•	•				
Detoxification		•	•	•	•	•	•			
Natural hazard regulation			•		•	•			•	
Cultural and amenity	•	•	•	•	•	•	•	•	•	•

Source: https://www.cbd.int/doc/case-studies/inc/cs-inc-iucn-nc-wb-en.pdf

Economic Value of Ecosystem Services ref

Economistsically classify ecosystem goods and services according to how they are used



Source: https://www.cbd.int/doc/case-studies/inc/cs-inc-iucn-nc-wb-en.pdf

Direct use values:

<u>Consumptive uses</u> ref

harvesting of food products

timber for fuel or construction

medicinal products

hunting of animals for consumption

<u>non-consumptive uses</u> ref

enjoyment of recreational and cultural activities

that do not require harvesting of products

Indirect use values ref**:** from ecosystem services

Natural water filtration - which often benefits people far downstream

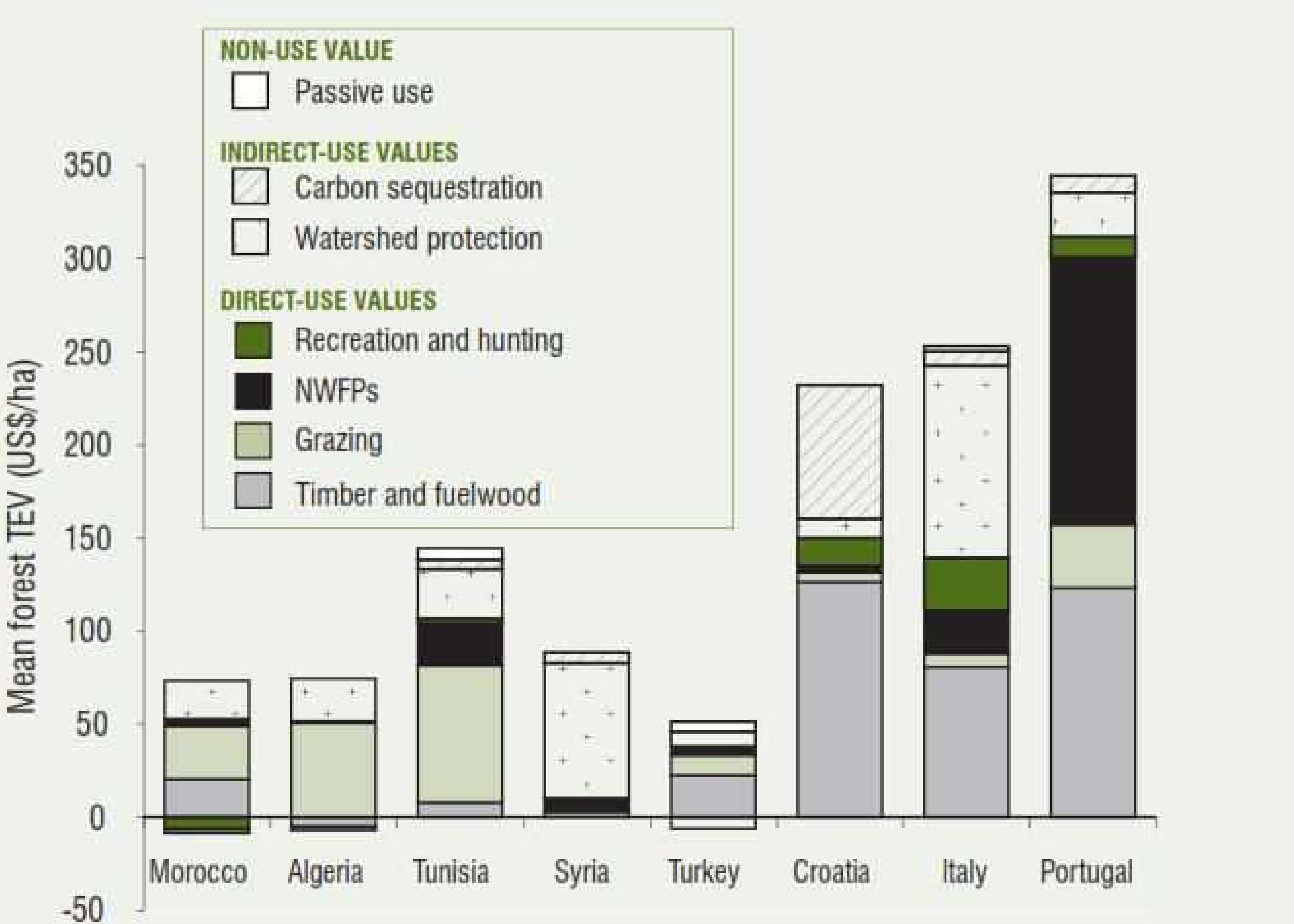
Storm protection - function of mangrove forests which benefits coastal properties and infrastructure

Carbon sequestration which benefits the entire global community by abating climate change.

Option values: preserving the option to use in the future ecosystem goods and services (provisioning, regulating, and cultural services) that may not be used at present ref.

Non-use values: refer to the enjoyment people may experience simply by knowing that a resource exists This kind of value is usually known as existence value (or, sometimes, passive use value) ref.

Benefits from forests in Mediterranean countries



Source: https://www.cbd.int/doc/case-studies/inc/cs-inc-iucn-nc-wb-en.pdf

Human System vs Ecosystem

Anthroposystem

- Very simple ecosystem; max. 3 trophic levels
- Open system; minimal recycling
- High efficiency of transfer of biomass to higher trophic level
- Monoculture; high density
- Few favored species encouraged; weeds destroyed
- Static, highly unstable
- Few people feed the rest- agriculture

Ecosystem

- Often highly complex food webs
- Often closed systems with significant recycling
- Low efficiency of transfer of biomass to higher trophic level
- High biodiversity
- Natural balance in species populations achieved adapted to conditions
- Robust, stable, dynamic, adaptable, evolving

Problems with Human Systems

- Dependent on very few species
  - 80% of world food from 15 species.
  - Human consume only 150 out of the estimated 50,000 edibles.
  - Out of 10,000 cereals, not one new has been cultivated in the past 2000 yrs.
- Inherently unstable
  - Irish Great potato famine (1845-47) wind-borne potato blight fungus; near total crop failure
  - 1 million dead due to starvation, typhoid and cholera
- Require constant inputs; pesticides, fertilizers, etc.
- Prone to pest attacks and failures
- Pollute soil, air, water
- Soil degradation and topsoil loss

Threats to Ecosystems

ref

- Habitat Destruction
- Pollution
- Eutrophication
- Invasive species
- Overharvesting
- UV Radiation

Ecosystems Conservation

ref

- Establishment of protected areas
- Rules that prohibit farming on sloping land or the use of pesticides
- Adopt more environmentally friendly land uses
- Discouraging them from adopting more harmful

Thank You

Extra Slides

Food Resources

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Center of Excellence in
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Amrita Vishwa Vidyapeetham,
Coimbatore -641112

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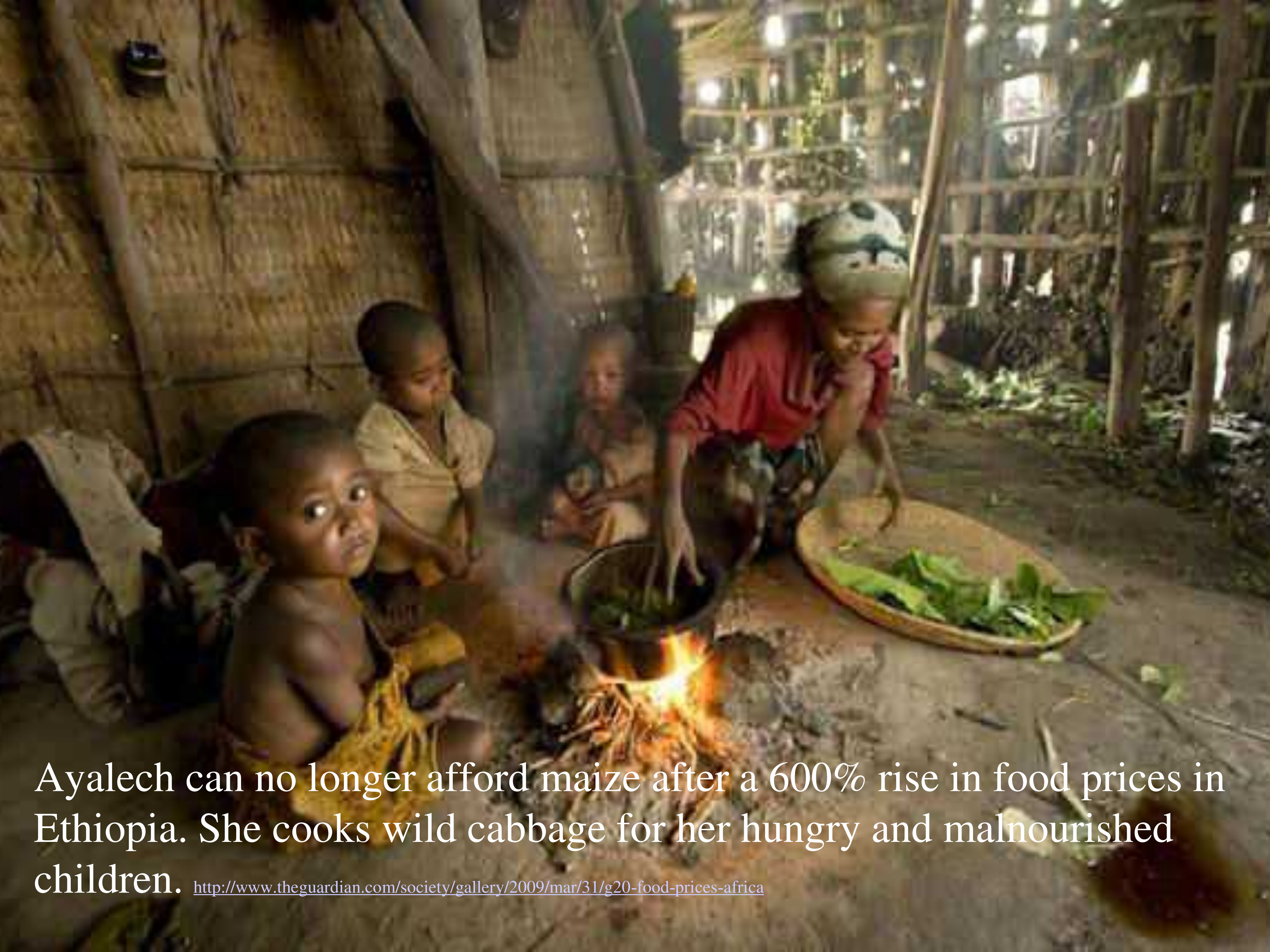


Ayalech can no longer afford maize after a 600% rise in food prices in Ethiopia. She cooks wild cabbage for her hungry and malnourished children. http://www.theguardian.com/society/gallery/2009/mar/31/g20-food-prices-africa

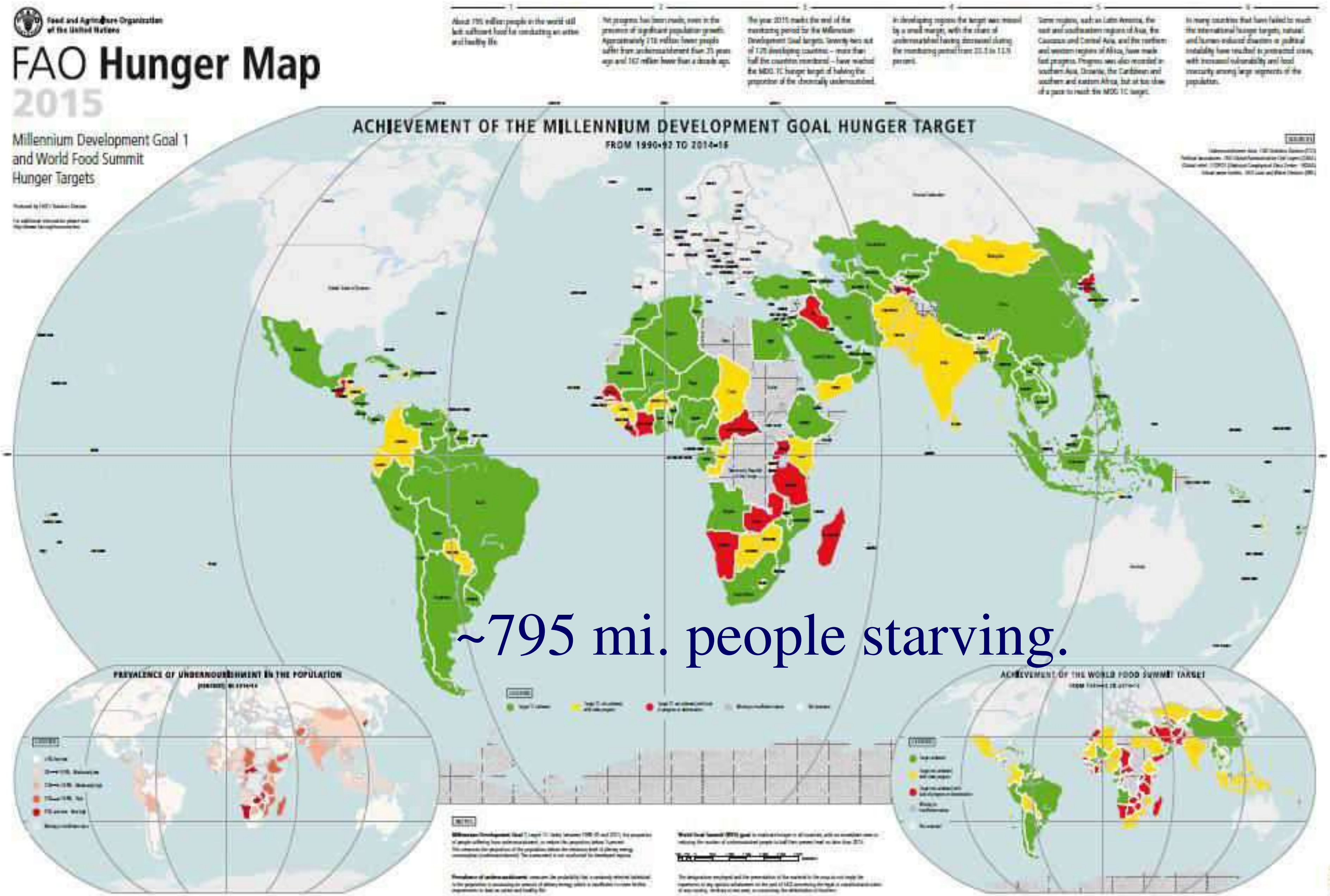
Forced to eat dirt!

*Brittle, gritty and revolting, **"mud cakes"** have been consumed by impoverished **pregnant women** seeking calcium, for years. But now the cakes have become a staple for **entire families** in Haiti.*

--The Hindu, Wed, Jul 30, 2008

Food and Health in India

- India ranked 15th in the 2011 Global Hunger Index (GHI) Report.[ref]
  - GHI went up from 22.9 to 23.7 between 1996 -2011.
- 60% of India's children below the age of three were malnourished (2005 report [ref])
  - 1 in 3 malnourished children in the world lives in India.
- 1.72 mi. children (<1 yr.) die each year before turning one.[18]
- Rampant diseases such as dengue, hepatitis, tuberculosis, malaria and pneumonia.[ref]



~795 mi. people starving.

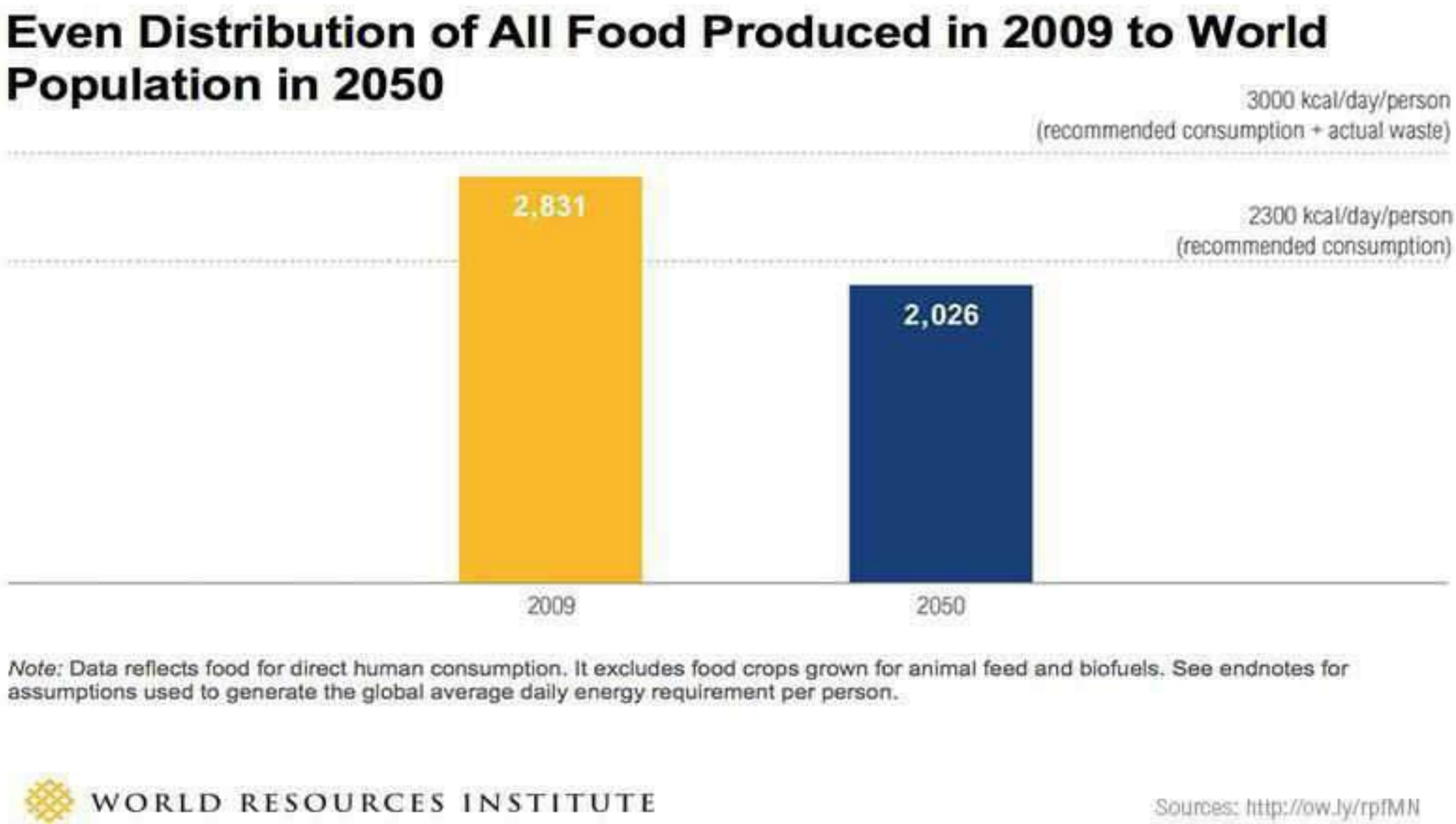
http://www.fao.org/3/a-i4674e.pdf

World Food Production

- Actually the world is producing enough food to feed everyone for now.
- Per capita food availability has risen:
  - From ~2220 kcal/person/day in the early 1960s
  - To 2790 kcal/person/day in 2006-08.
- Yet many people in the world still do not have sufficient income to purchase (or land to grow) enough food.
- Besides, population is projected to grow from 7bi. to 9.6 bi. (2012-2050).
- >50% will occur in sub-Saharan Africa, where 25% population is currently undernourished.

http://www.worldhunger.org/articles/Learn/world%20hunger%20facts%202002.htm

Per Capita Food Availability



http://www.wri.org/blog/2013/12/global-food-challenge-explained-18-graphics

Inequality in Society

- Nearly 1/2 of the world's population (> 3 bi.) live on <$2.50/day.
- More than 1.3 bi. <$1.25 a day.
- 80% of the world population lives on less than $10 a day.
- 1 bi. children worldwide are living in poverty.
- 22,000 children die each day due to poverty (UNICEF)
- 805 mi. worldwide do not have enough food to eat.
- The world's 358 billionaires have assets exceeding the combined annual incomes of countries having 45 percent of the world's people.

http://worldcentric.org/conscious-living/social-and-economic-injustice

Spare Arms and Feed the Hungry

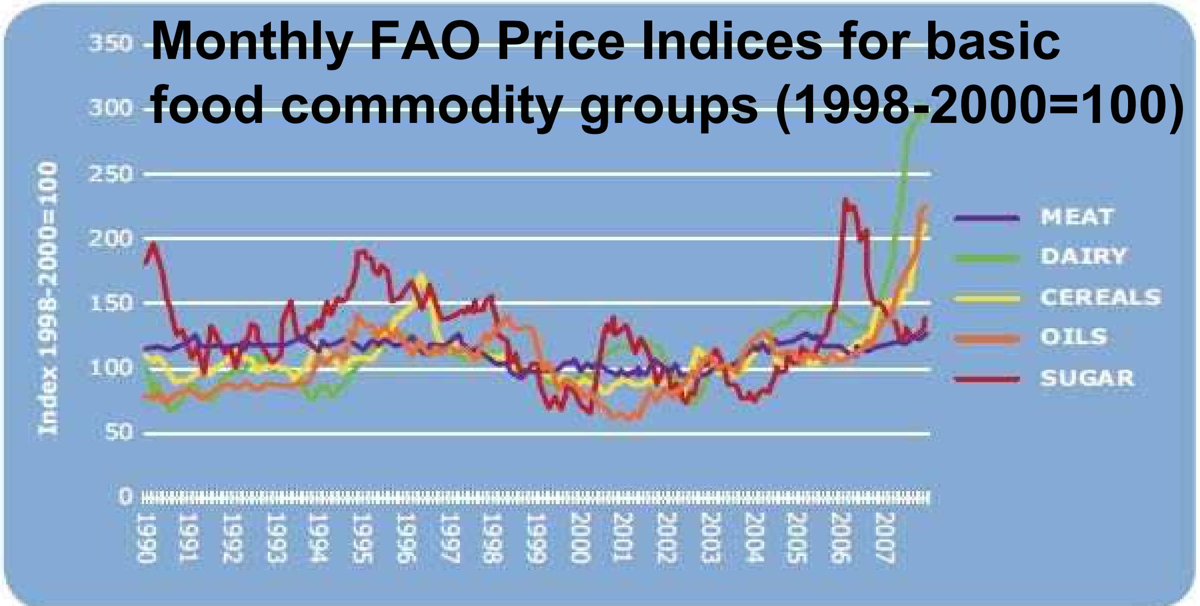
Is solving the hunger problem impossible?

….Perhaps not!

- For the price of one missile, a school full of hungry children could eat lunch every day for 5 years
- 100 mi. child hunger deaths (over 1 decade: 1990-2000) could be prevented for:
  - the price of 10 stealth bombers, or
  - World military expenditure in 2 days!

STAPLE PRICES TRIPLE AS MUCH OF THE WORLD'S FOOD SUPPLY IS DIVERTED TOWARDS FUEL CONSUMPTION

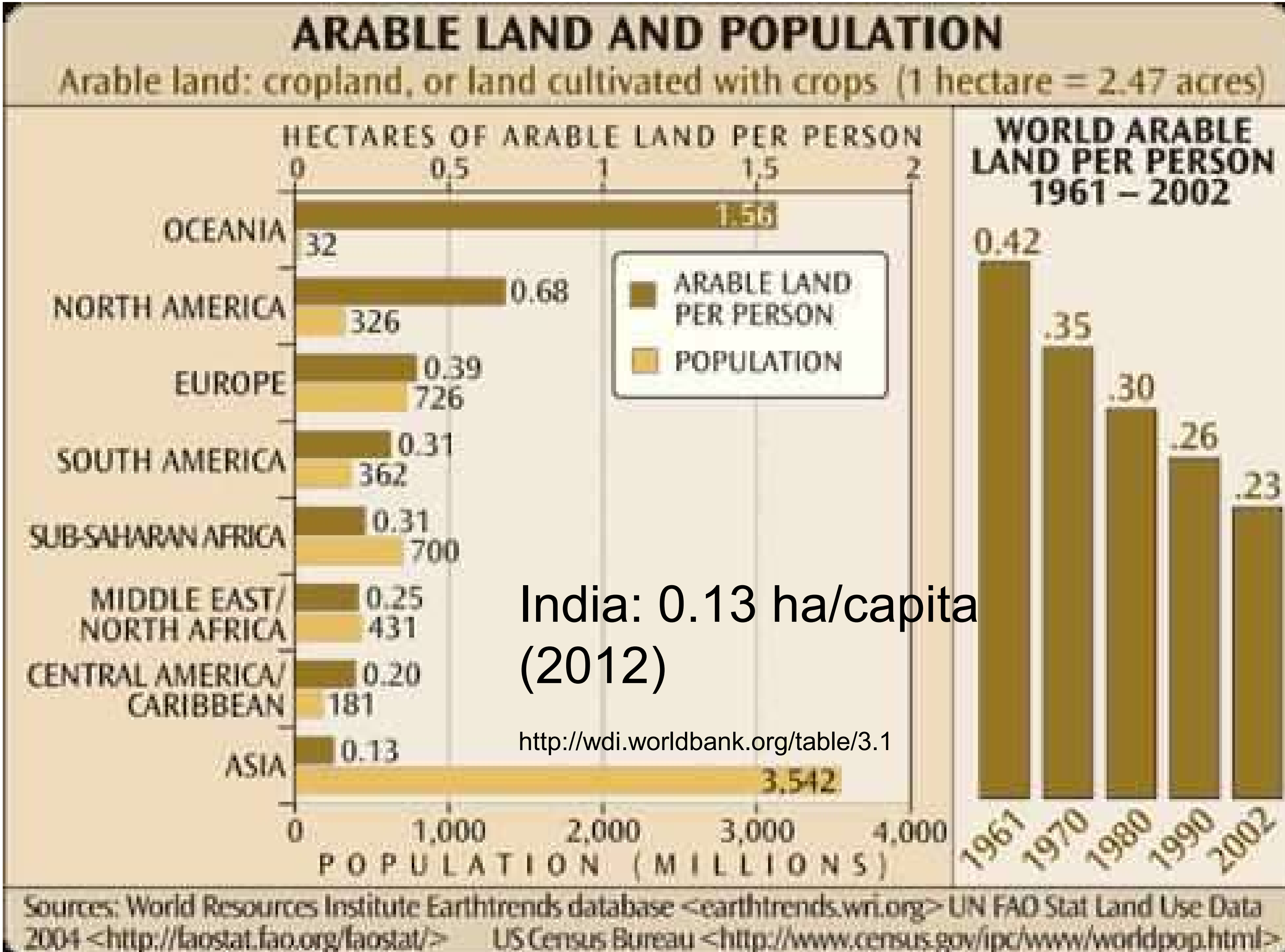
Rising and Fluctuating Food Prices



The poor consumers and the poor farmers are the worst affected.

- Causes:
  - Losses in yields due to adverse weather conditions
  - Fluctuations in energy costs
  - Increased demand due to rising population.
  - Increased preference for meat and dairy products.
  - Diversion of food crops and land for biofuel production
  - Financial speculation and price fixing.[ref]
  - Policy factors.

http://www.fao.org/docrep/012/i1059e/i1059e00.pdf, http://www.helsinki.fi/taloustiede/Abs/DP35.pdf



India: 0.13 ha/capita (2012)

http://wdi.worldbank.org/table/3.1

Agricultural Yields in India

- Roughly 60% of India's land is under agriculture.
- Indian agricultural yields are generally low due to:
  - Soil and land degradation.
  - Low percentage of irrigated land (only 35% of arable land).
  - Low agricultural technology and know-how.

http://wdi.worldbank.org/table/3.2
http://en.wikipedia.org/wiki/Agriculture_in_India

Food Wastage and Spoilage

- 1/3rd of world's food is wasted [ref]; while 0.8 bi. people go hungry.
- Millions of tons of foodgrains rot in warehouses
- Cold-storage facilities are available for only 10% of India's perishable food [ref]. 370 mi. tons of perishables at risk.
- Large quantities of prepared food is wasted world over.

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Threats to Future Food Security

- Rising population
- Unequal distribution
- Diversion of foodgrains as livestock feed and biofuels.
- Reduced productivity of important agricultural regions world-wide due to desertification, droughts, land degradation, pollution…effects of industrial agriculture, deforestation, industrialization and urbanization.
- Global climate change: droughts, famines, floods and severe weather episodes, shifting temperature, rainfall and humidity patterns
- Food Wastage and Spoilage
- Genetic pollution due to GMOs
- Loss of crop and wild biodiversity

Solutions???

- So, we must grow more food…drastically improve productivity through technology—
- Industrial agriculture: mechanization, chemical fertilizers…pesticides… biotechnology …genetic engineering…
- Technology has solved so many problems for us…surely this is no different!…
- Right????? ……………………….OR NOT??
- When in doubt, lets look at our leaders

What are our leaders doing?

- G8 Summit on Global Food Crisis and Poverty Alleviation in 2008.
- Leading industrialized nations on the island of
- Hokkaido, Japan

Summit that's hard to swallow

World leaders enjoy an 18-course banquet as they discuss how to solve

Global Food Crisis

http://www.dailymail.co.uk/news/article-1032909/Summit-thats-hard-swallow--world-leaders-enjoy-18-course-banquet-discuss-solve-global-food-crisis.html

Just what the starving millions need!

Lunch & Dinner Menu

Working Lunch

White asparagus and truffle soup
Chaud-froid of Kegani crab
Almond oil foam and tapenade
Supreme of chicken, with stuffed thigh, nuts and orange savoury and beetroot foam
Cheese selection
Peach compote, ice-cream and raspberry coulis
Coffee and petits fours

Wines

Chateau Grillet 2005
Chambolle-Musigny 2005

Dinner

Corn and caviar
Smoked salmon and sea urchin
Hot onion tart
Winter lily bulb and summer savoury
Kelp-flavoured beef and asparagus
Diced tuna, avocado and soy sauce jelly, and herbs
Boiled clam, tomato, shiso in jellied clam soup
Water shield and pink conger with soy sauce vinegar
Boiled prawn with tosazu vinegar jelly
Grilled eel and burdock
Fried goby fish with soy sauce and sugar
Hairy crab bisque soup
Grilled bighand thornyhead fish with pepper sauce
Milk-fed lamb flavoured with herbs and mustard, and roast lamb with cepes and black truffle
Cheese, lavender honey and caramelised nuts
G8 'Fantasy' dessert
Coffee and candied fruits and vegetables

Wines

Le Reve Grand Cru Brut/La Seule Gloire Champagne
Sake/Isojiman Shuzo Shizuoka
Corton Charlemagne 2005/Louis Latour Bourgogne
Ridge California Monte Bello 1997,
Tokaji Esszencia 1999

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Theoretical Solution

- Since presently the world already produces enough food, the hunger problem can be solved theoretically, to a large extent by better and more equitable distribution.
- …easier said than done!

Food Distribution: Haves and Have-nots

- Excess food production in developed countries (low population densities); insufficient food production in developing countries (high population densities).
- High food prices: unaffordable to the poor countries and the poor people in a country.
- Developed countries must enable purchase of food by poor countries at subsidized prices, while offering the producers a fair price for their crop.
- The govts. and state depts of poor countries should effectively distribute food to the poor masses at subsidized rates.

Food Distribution and World Debt

- The poorest 52 countries (37 in Africa) $376 bi. debt.
- This forces the countries to use their land for growing cash crops for export.
- This, prevents solving the hunger problem.
- Cancelling world debt would will allow them to recover their economy, agriculture, and technology to solve their food crisis.
- Will the present world economic order allow this to happen?

Food Distribution: Wars

- War, (esp. civil war) is one of the major causes for persistent hunger in a country…often triggered by resource control issues between govts. and dissenting groups.
- Destroys or disrupts agriculture, economy, food distribution systems, transportation etc. for extended periods.
- Often prevents aid (food and medical aid) entering or reaching those areas of need.

Food Distribution: Wars

- Wars divert a nation’s resources to funding the war process.
- There is little money to fund equipment, technology to increase food supplies, or to afford imports of food from abroad.
- Peace negotiations in hunger stricken areas help to allow aid in and the country to focus its time and resources onto solving their hunger problems.

- More tangible improvements in food distribution…..

Food Distribution: Market Facilities and Management

- Public market facilities are inadequate or in a derelict condition affecting the local economy, small traders, and consumers.
- Many food traders occupy roads around markets.
- Traders are taxed by the govt. without providing market facilities.
- Rat and pest-infested warehouses…unhygenic and
- Insufficient, ill-designed, ill-maintained and high-priced cold storage.
- This leads to high spoilage of food and hygiene and safety problems.

Food Distribution: Market Facilities and Management

- Poor transportation facilities and road infrastructure, delays at octroi and other check posts, limited refrigerated transportation facilities
- Regulation and Taxation: Fruit and vegetables sometimes have to transported through a series of wholesale markets, compulsory middlemen, and a series of market and municipal taxes, leading to high prices.
- Corruption in the subsidized distribution system leads to diversion of the subsidized food to the open market at a high prices.

Food Distribution: Food Miles

- “Food miles” - the total distance in miles the food item is transported from field to plate
- A convenient indicator of sustainability
- Has led to a general movement towards local production and local consumption in order to minimize food miles.
- It raises fundamental questions about the sustainability of the globalised food trade and the increasing concentration of the food supply chain and distribution in the hands of fewer and fewer transnational corporations.

Food Distribution: Food Miles

- Sourcing food locally and preferring seasonal foods. (Avoid foods with high food miles and out-of-season foods)
- Local, regional and national food self-sufficiency should be encouraged.
- Internalising the social costs of transport to reflect the costs to society of pollution, congestion, accidents, noise and so on, in the prices paid by transport users.
- Preventing irrational food trade: identical produce is simultaneously imported and exported between developed countries in Europe and America.
- In the name of ‘free trade’, poor and populous countries cultivate cash crops for export to advanced countries, and import their own food supplies.

Food Distribution: Food Miles

- This benefits supermarkets, corporations, traders, middlemen, etc.
- But an even impoverish the farmer by forcing him into the debt trap of industrial agriculture and undermining their own food security.
- It leads to the lengthening of the supply chain, high spoilage rates, high prices for the consumers, high GHG emissions during transportation, refrigeration etc.
- Need to improve the wider sustainability of the food supply chain e.g. ethical trading, improved energy efficiency in the local food sector.
- Reducing transport impacts e.g. cleaner vehicles, improved logistics, rail freight, etc.

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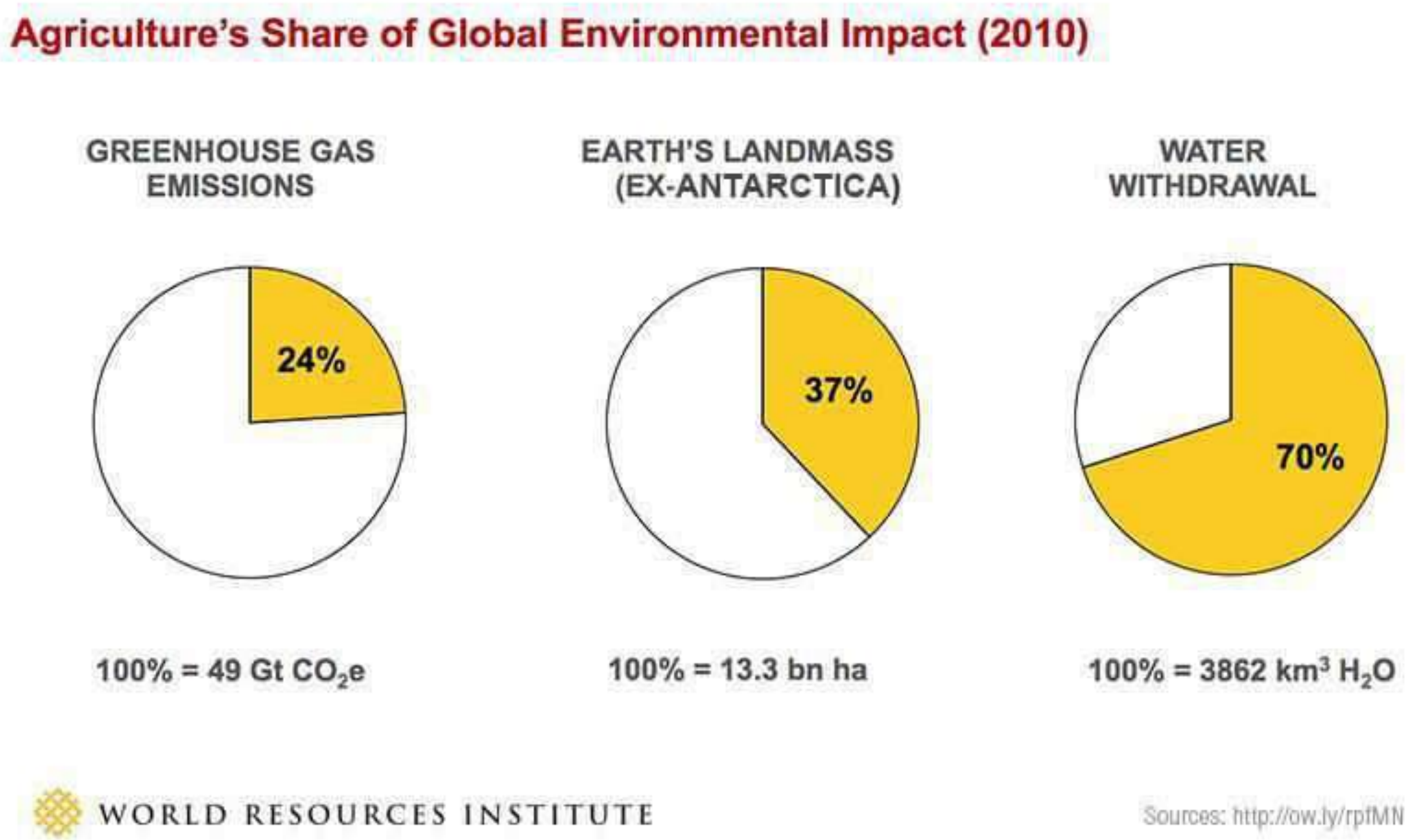
Real Solutions to the Food Crisis

- A more fundamental, practical and sustainable solution to the food crisis is complex.
- There are no simple solutions
- It requires a deep understanding of conventional (industrial) agriculture, its economics, socio-economic issues and sustainability
- It also requires a deeper understanding of natural processes, ecology, biodiversity, evolution etc.

- Can industrial agriculture solve the food crisis?



http://www.wri.org/blog/2013/12/global-food-challenge-explained-18-graphics

Conventional Farming

Activity	**Environmental Impact**
Land clearing	Loss of biodiversity and habitats, topsoil loss, reduced water recharge, CO_2 emissions.
Heavy Equipment	Soil compaction, waterlogging, high cost, oil dependence
Ploughing	Loss of soil structure, porosity, moisture, moisture carrying capacity, biomass/humus, biota; CO_2 emissions
Fertilizers	Fast plant growth & micronutrient deficiency, loss of soil fertility, and biota, eutrophication, nitrates pollution.
Pesticides, Herbicides	Toxicity to man & environment, POC, increased resistance in pests and weeds, ozone depletion (MeBr)
Irrigation	Waterlogging, salination, evaporative losses, CH_4 emissions

Corporate Monopolization of Agriculture

- By end of 2001 worldwide:
  - Top 10 agrochemical corporations…84% of the $30 bi. market
  - Top 10 veterinary pharmaceutical companies…60% of the $13.6 bi. world market.
  - 10 pharmaceutical companies…48% of the $317 bi. world market.
- Only 6 corporations controlled 98% of the world's market in GM crops.
- The same 6 firms also controlled 70% of the world's pesticide market.
- 94% of all GM crops grown worldwide were from 1 company's germplasm: Monsanto's.

http://www.greens.org/s-r/33/33-03.html

"…The agricultural sciences have over time become increasingly subordinated to capital and…this ongoing process has shaped both the content of research and, necessarily, the character of the products."

–Jack Kloppenberg rural sociologist in *First the Seed.*

“What is profitable affects, or even determines, what is ‘scientifically true.’

–Hugo de Vries (biologist)

Are We Violating the Constitution?

- Pesticide use violates the right to life enshrined in Article 21 in our Constitution
- Article 47 of the Constitution:

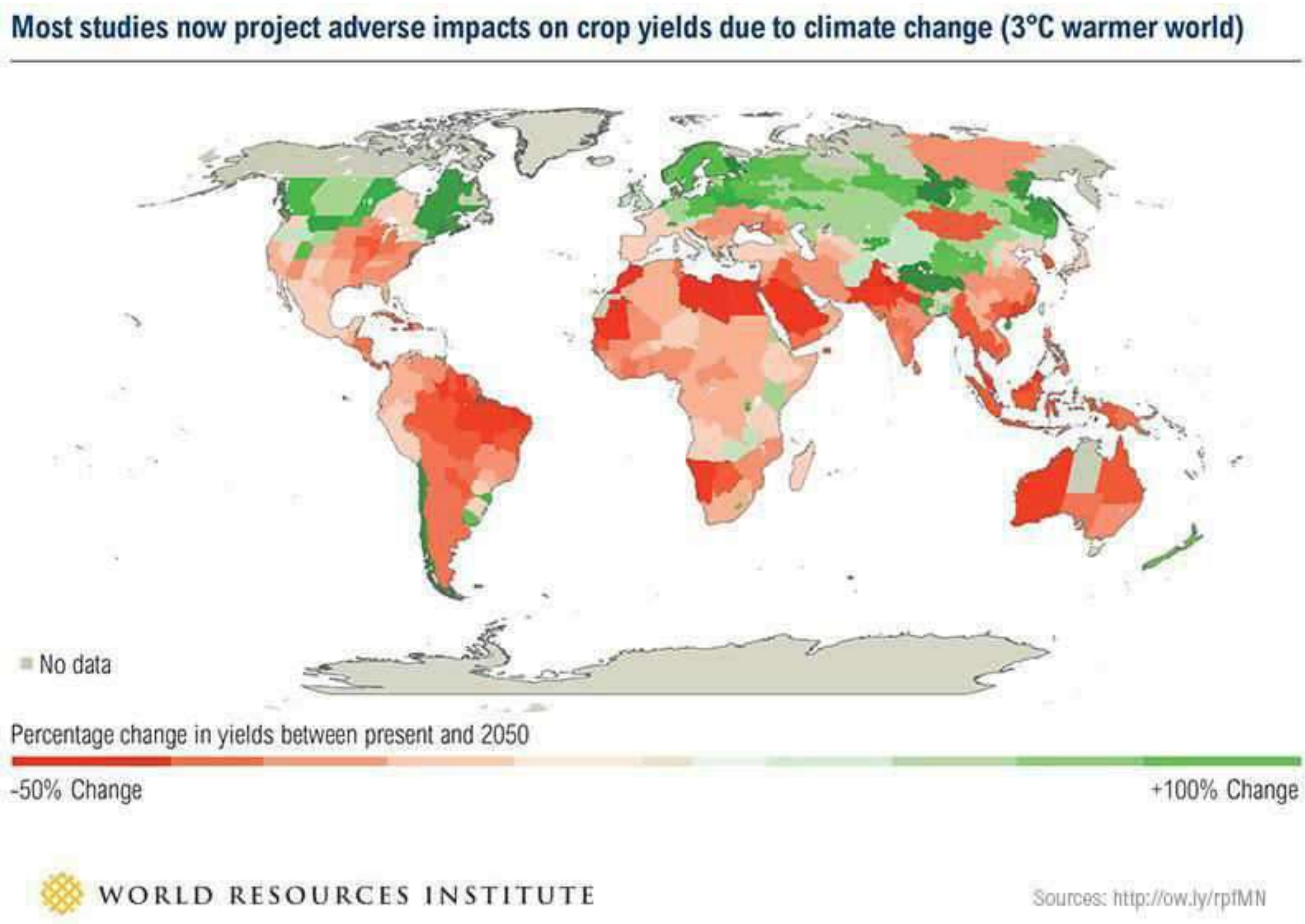
The State shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties and in particular, the state shall endeavor to bring about prohibition of the consumption except for medicinal purposes of intoxicating drinks and of drugs, which are injurious to health.

—Ravi Agarwal, Director, Srishti

More Impacts

- Devastation of natural ecosystems
- Desertification and loss of topsoil soil
- Unfair practices of fertilizer and pesticide companies causing social injustice and suicides
- Benefits large corporations and middle men
- Impoverishes the poor farmer and makes the consumer unhealthy

Climate Change To Reduce Yields



Impacts on Land

In the past 20 yrs.:

- Tropical forests lost to agriculture: 15 mi. ha/yr
  - tremendous loss of genetic diversity.
- Soil erosion and other forms of land degradation: 5-7 mi. ha of farming land/yr.
- Waterlogging and salination: 1.5 mi. ha/yr.
- Other damaged land: 30 mi. ha

http://www.i-sis.org.uk/FAOPromotesOrganicAgriculture.php

Impacts on Land: Irreversible Land Degradation

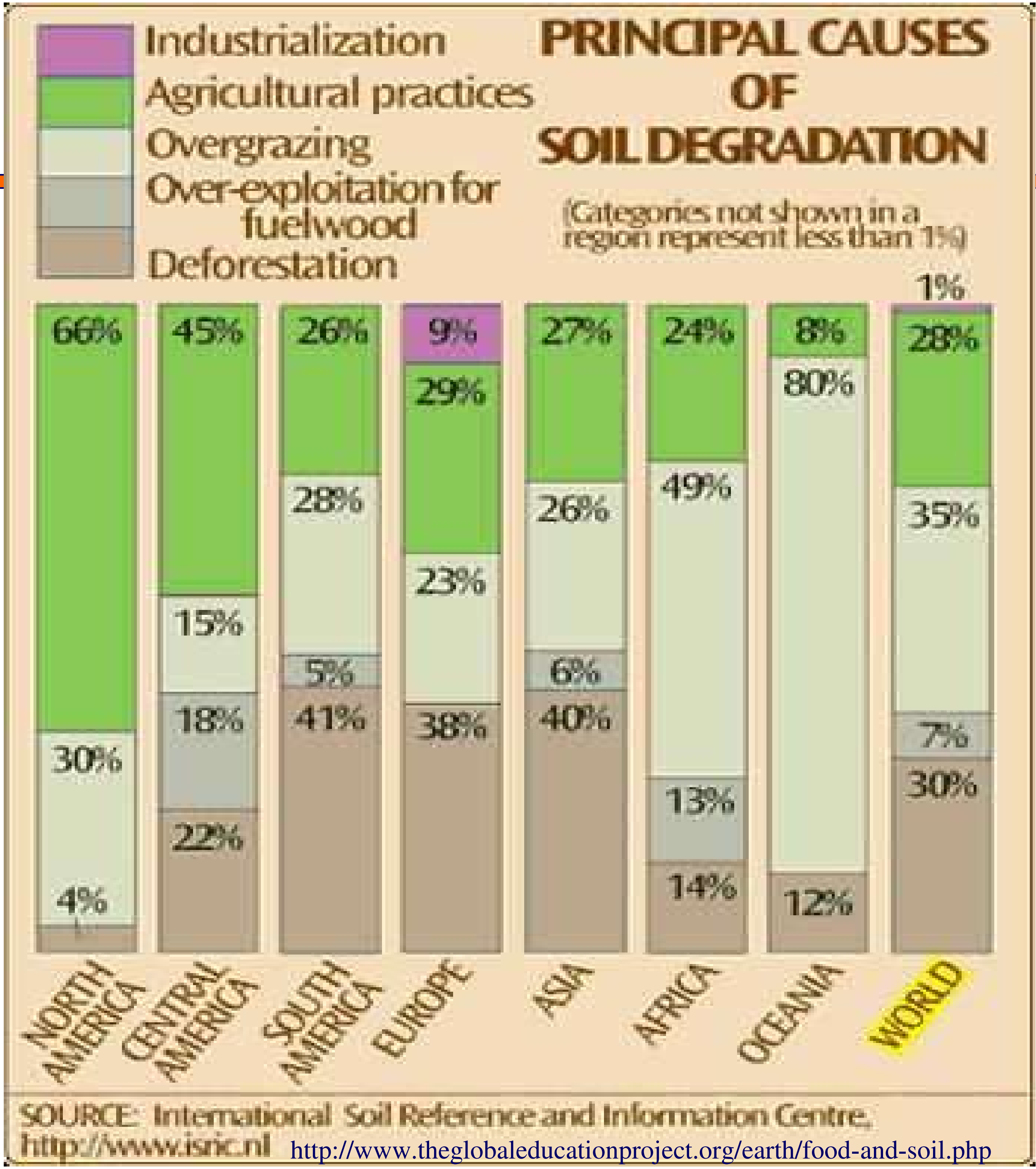
- South Asia: ~ 50% land degraded and useless for food production.
- China: 27% irreversible loss of land for agriculture, loss rate (2,500 sq. km /year).
- Madagascar: 30% of the arable land irreversibly barren.

- ^ a b c Ron Nielsen, *The Little Green Handbook*, Picador, New York (2006) ISBN 0-312-42581-3
- ^ UNEP, *Global Environmental Outlook 2000*, Earthscan Publications, London, UK (1999) which may also be viewed at http://www.unep.org/geo2000/ov-e/index.htm, including an optional PDF download

World Soil Degradation

About 2 bi. ha of soil, (~15% of Earth's land area), an area larger than the United States and Mexico combined, have been degraded through human activities.

http://www.theglobaleducationproject.org/earth/food-and-soil.php



http://www.theglobaleducationproject.org/earth/food-and-soil.php

Soil Carbon Sink

- Soils contain ~1,395 gigatons of C; Vegetation ~650 gigatons, atmosphere ~750 gigatons…(*United Nations Food & Agriculture Organisation*)
- "Soil organic carbon is the largest [terrestrial C] reservoir in interaction with the atmosphere."
- It includes plant litter, burnt char, other biomass and humus (organic carbon polymers, lignin, aliphatic compounds, waxes and terpenoids)
- More organic matter tends to accumulate in the litter and soils of colder regions boreal forests and Taiga.

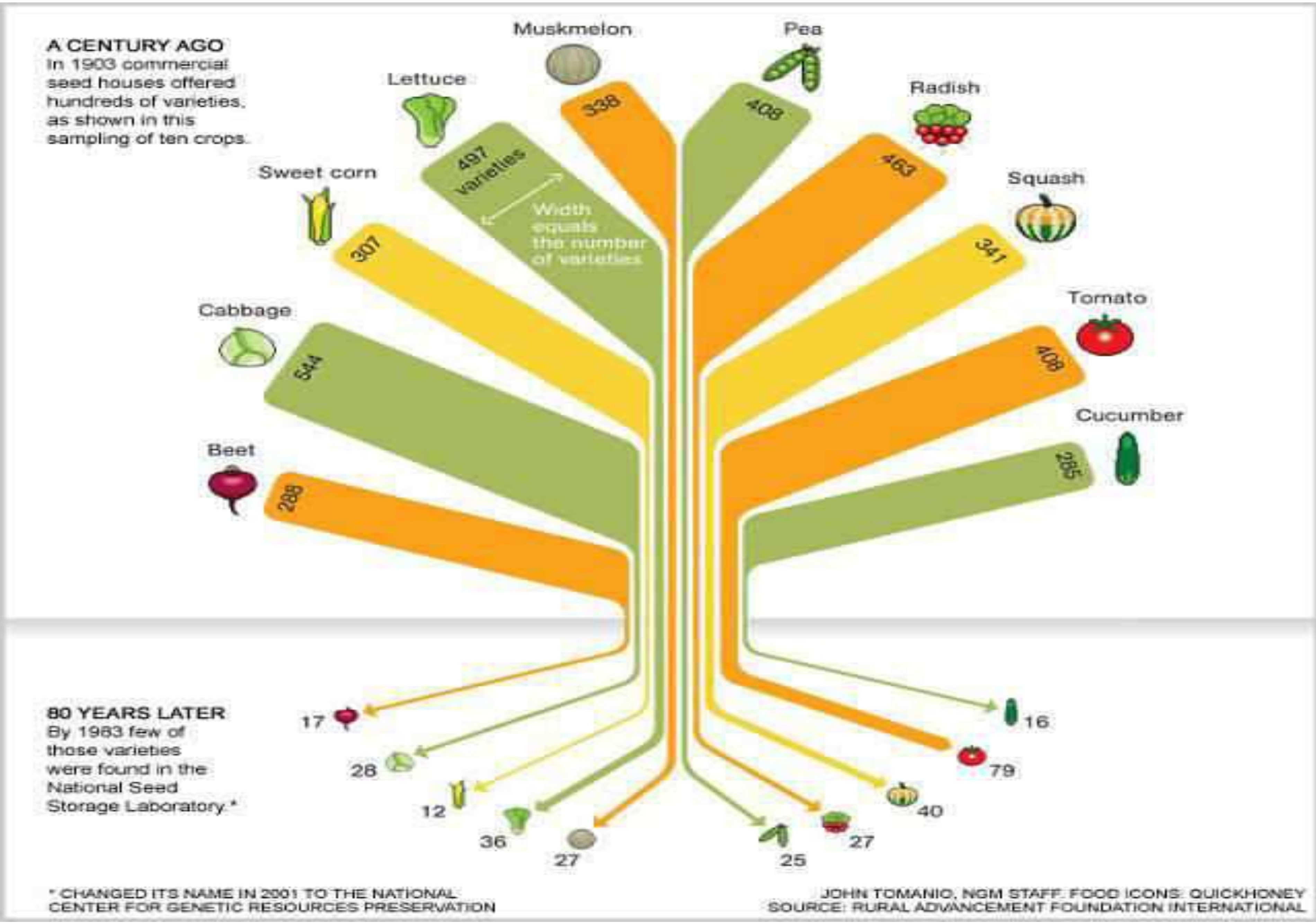
- http://www.nature.com/nature/journal/v298/n5870/abs/298156a0.html
- ^ Swift, Roger S. (November 2001). "Sequestration of Carbon by soil". *Soil Science* **166** (11): 858–71. doi:10.1097/00010694-200111000-00010. http://www.soilsci.com/pt/re/soilsci/abstract.00010694-200111000-00010.htm.
- ^ Batjes, Niels H. (1996). "Total carbon and nitrogen in the soils of the world". *European Journal of Soil Science* **47**: 151–63. doi:10.1111/j.1365-2389.1996.tb01386.x.
- ^ Klaus Lorenza, Rattan Lala, Caroline M. Prestonb, Klaas G.J. Nieropc (15 November 2007). "Strengthening the soil organic carbon pool by increasing contributions from recalcitrant aliphatic bio(macro)molecules". *Geoderma* **142** (1-2): 1–10. doi:10.1016/j.geoderma.2007.07.013.

Loss of Soil Carbon

- Agricultural practices such as tilling, exposing soil to the sun and burning lead to high soil temperatures, disruption of plant root systems, destruction of soil microflora and fauna…leading to oxidation of humus—C-emissions.
- Deforestation and burning leads to huge emissions of carbon.
- Water logging/submergence of forests and soils (esp. peat bogs) releases huge amounts of carbon in the form of CO_2 and CH_4.
- C-sink capacity of the world's agricultural and degraded soils is 50 to 66% of the total historic carbon loss of 42 to 78 gigatons C

Loss of Crop and Wild Biodiversity

- Monopolization of agriculture by seed and agrochemical MNCs
- Extensive crop monocultures
- Loss of highly adapted and diverse indigenous crops and landraces
- Reduced resilience to changing climate
- More susceptible to MNCs power politics
- Reduced independence for farmer.
- Debt trap



http://g.fastcompany.net/multisite_files/codesign/imagecache/inline-large/post-inline/food-variety-tree-754.jpg

Risks of Genetically Modified Organisms (GMOs)

- "Genetic engineering is not merely causing genetic pollution of biodiversity and creating bio-imperialism, monopolies over life itself. It is also causing knowledge pollution—by undermining independent science, and promoting pseudo science. It is leading to monopolies over knowledge and information."

–Dr Vandana Shiva | Author, Activist, Pioneer, Scientific Advisor, Mother

Navdanya www.navdanya.org/

Watch Video: Seed Freedom **(2.29)**

External Costs of Industrial Agriculture

- Industrial agriculture and the green revolution has masked significant externalities, affecting natural resources and human health as well as agriculture itself.
- Environmental and health problems associated with agriculture have been increasingly well documented
- External costs of agriculture in the UK alone have been estimated as 1.1–3.9 bi. pounds/yr.
- As the external costs of farming are not internalized in the price of food, tax payers (or more likely the future generations) will have to pay the bill that is getting bigger every day.

Subba Rao, I. V., Soil and environmental pollution – A threat to sustainable agriculture. *J. Indian Soc. Soil Sci., 1999,* ***47, 611–633.***
Pretty, J., The real costs of modern farming. *Agric. Syst., 2000,* ***65,*** 113–136

Summing Up Corporate Agriculture

- Agriculture related firms form a nexus: Seed firms; agrochemical concerns; agroforestry; veterinary services and medicine; food industry; biotechnology; pharmaceuticals; nanotech, bioinformatics.
- Capitalized market valued between $2.5–4 trillion.
- Approximately 12 firms control 75% of this market.
- These corporations are not committed to humanitarian ends—i.e., feeding and curing people, or tackling hunger or disease.
- Instead, they are committed to feeding themselves and their shareholders increasing profits, making well people better, and fomenting simultaneously social sickness and corporate wealth.
- The name of the game is, privatize benefits and socialize costs.

http://www.greens.org/s-r/33/33-03.html

Death Trap of Industrial Agriculture

- 70% of all Indians are small marginal farmers with land holdings of a few acres or less.
- Giant seed and agrochemical MNCs market expensive seeds to them promising extraordinary yields, quality and profits.
- However, the crops are addicted to high water use and agrochemical inputs such as fertilizers and pesticides …often marketed by the same MNCs.
- Majority of introduced commercial crops (esp. hybrids and GMOs) are not adapted to local conditions.

Watch Video: Nero's Guests (56min)

Death Trap of Industrial Agriculture

- These crops are more vulnerable to climatic changes, disease and pest attack.
- Farmers are urged to turn traditional diverse farms into cash crop monocultures.
- MNCs also aggressively market farm machinery in the name of higher productivity and profits.
- Forces farmers to borrow; oft. at unreasonably high interest rates (30-60% p.a.) from private moneylenders.
- Produce is sold by farmers in a market controlled by traders and MNCs, and which is subject to price-fixing and the vagaries of government policies.

Death Trap of Industrial Agriculture

- Farmers cannot indulge in "unauthorized seed-saving”. Patent violation…lawsuits.
- F1 hybrids, Terminator Technology (sterile seeds).
- Must purchase seed for the next season from the seed corporation…at ever-increasing prices.
- Newer seeds need higher and higher inputs of newer and deadlier pesticides and fertilizers…purchased from the same MNCs.
- Repeated borrowing becomes necessary
- Crop failures or inability to sell crops at a suitable price causes the debt to spiral out of control…farmer suicides.

Death Trap of Industrial Agriculture

- The excessive fertilizers lay waste the land…depleted soil carbon, deficiency of micronutrients, loss of soil biota, eutrophication and pollution of waterways.
- Excessive irrigation: water logging, salinization of soils, groundwater depletion.
- Excessive pesticides, herbicides: pollution of air, land and water,
- Heavy farm machinery: soil compaction (plough pan) water logging.

Indian Farming: Cost Breakup

S. No.	Item	%Cost
1.	Seed	20
2.	Chemicals	32
3.	Diesel (groundwater pumping)	10
4.	Labor	38
	TOTAL INPUT COST	**100**

- Avg. potato and onion farming in Northern India
- http://www.globalresearch.ca/index.php?context=va&aid=3204

Indian Farming: Cost Breakup

- Assuming 4.4 metric tonnes/acre each of potato and onion
- 5 yr-avg. ex-farm prices is about Rs. 200/quintal for potato and Rs. 250/quintal for onion.
- Does not include post-harvest wastage: 10 to 40% on account of drying, rotting, and losses in transit (various government estimates).
- Once in ~3 yrs. prices crash by as much as 30-50%, largely engineered by traders, leaving farmers deeply in debt.

Indian Farming: Cost Breakup

Input Rs./acre	Output Rs./acre	Interest owed	Profit Rs./acre	Remarks
38,000	44,500	0	6,500	Self-financed, Hired Labor
23,560	44,500	0	20,900	Self-financed, Family Labor
38,000	44,500	6,840	-340	50% inputs financed @36% p.a., Hired Labor
23,560	44,500	6,840	14,100	50% inputs financed @36% p.a., Family Labor
38,000	31,150	6,840	-13,690	50% inputs financed @36% p.a. 30% crash in market price
23,560	31,150	6,840	750	50% inputs financed @36% p.a. 30% crash in market price, Family Labor

http://www.globalresearch.ca/index.php?context=va&aid=3204

Indian Farming: Cost Breakup

- Small and marginal farmers cannot store the produce or afford warehouse charges.
- Distress sale further erodes a farmer's financial viability.
- Those who store their surplus end up losing 10-20% stock due to spoilage and drying shrinkage.
- This neutralizes any gains through seasonal price fluctuation.

Ineffective Government Policies

"The talk of helping farmers with greater access to market, a promise that has been repeated by every politician and every Agriculture Minister since 1947, is unlikely to resolve the problem of assured minimum income. Small and marginal farmers can't benefit from market access; rather the market left to its own devices works against their interest."

—Arun Shrivastava, Global Research, 2006

http://www.globalresearch.ca/index.php?context=va&aid=3204

Indian Farming: Winners and Losers

Income from…	USD / acre/yr
Seeds	168.89
Diesel	84.45
Fertilizers and pesticides	270.23
Total to corporations	**523.57**

Corporations

Net income	USD /acre/ yr
With hired labor	144.00
With family labor [excluding cost of capital]	464.00

Farmers

70% of Indians

Industrial Agriculture Leads to Food Insecurity

- Unsustainable yields.
  - Yields decline due to soil degradation, pest attack (pesticide resistance)
  - Increased agrochemical use becomes necessary…expensive
- Needs excessive irrigation…resource depletion and land degradation.
- Leads to crop monocultures: inherently unstable
- Degradation of prime agricultural lands, loss of topsoil—a permanent loss.
- Poor resilience to changing abiotic and biotic factors…global climate change.

Industrial Agriculture Leads to Food Insecurity

- Serious and widespread preconsumer and consumer health effects of pesticides, nitrate contaminants.
- Eutrophication and toxification of precious and scarce water resources.
- Inequitable food distribution inspite of surplus production due to MNC domination, politics and govt. policies.

Outline

- Dimensions of the Food Crisis
  - Hunger, poverty, production, distribution
- Threats to Food Security: Present and Future
- Solutions to the Food Crisis
  - Theoretical (Present) Solution
    - Food Distribution
  - Real Solutions
    - Industrial Agriculture?
    - **Alternative Agriculture**
    - Vegetarianism
    - What Can You Do?

Human System vs Ecosystem

Anthroposystem

- Very simple ecosystem; max. 3 trophic levels
- Open system; minimal recycling
- High efficiency of transfer of biomass to higher trophic level
- Monoculture; high density
- Few favored species encouraged; weeds destroyed
- Static, highly unstable
- Few people feed the rest- agriculture

Ecosystem

- Often highly complex food webs
- Often closed systems with significant recycling
- Low efficiency of transfer of biomass to higher trophic level
- High biodiversity
- Natural balance in species populations achieved adapted to conditions
- Robust, stable, dynamic, adaptable, evolving

Problems with Human Systems

- Dependent on very few species
  - 80% of world food from 15 species.
  - Human consume only 150 out of the estimated 50,000 edibles.
  - Out of 10,000 cereals, not one new has been cultivated in the past 2000 yrs.
- Inherently unstable
  - Irish Great potato famine (1845-47) wind-borne potato blight fungus; near total crop failure
  - 1 million dead due to starvation, typhoid and cholera
- Require constant inputs; pesticides, fertilizers, etc.
- Prone to pest attacks and failures
- Pollute soil, air, water
- Soil degradation and topsoil loss

Alternative to Industrial Agriculture

- Adopt low input sustainable/organic farming methods
- Use indigenous or traditional crops
- Improve farm diversity
- Use organic, biological pest management methods.

Alternative Farming—Different Preoccupations

- Sustainability—Sustainable farming
- Ecological—Ecological agriculture
- Mimicking nature—Natural
- Chemical free—Organic
- Avoiding tillage—No till, Zero tillage, minimal tillage
- Biodynamic, Rishi Krishi

Alternative Farming

Characteristics	Environmental Benefit
No-till, minimal tillage	Retains soil structure, porosity, organic matter, biota, high percolation, C-sequestration.
Minimal earthmoving	Minimize habitat and topsoil loss, C-sequestration.
Minimal Equipment	Reduced capital costs, compaction, and oil dependence
Ground Mulch, Manures, residue	Reduced cost, evaporation. Improved pest resistance, better product and keeping quality, balanced fertilization, C-sequestration.
Interplant	More crop diversity, resilience to pest attack, maintenance of soil fertility

Alternative Farming

Characteristics	Environmental Benefit
Natural Pesticides/ predators	Low or no toxicity to humans, preserves and improves biodiversity
Beneficial Organisms, earthworms, Bees	Better fertilization, pollination, yields, supplementary income
Local crops	Excellent adaptation to local conditions, natural pest resistance, Not addicted to fertilizers and pesticides, increased crop diversity…resilience
Minimal irrigation	Low salinization, low depletion of water resources, low CH4 emissions due to waterlogging

Farm Diversity

- High farm diversity (in crops and enterprises) reduces economic risk.
  - Plant a variety of crops
  - Intercrop with nitrogen fixing crops
  - Follow crop rotation with nitrogen fixing crops or pasture grasses.
  - Keep livestock
  - Start value-added enterprises
- Farms become more self-sufficient in terms of nutrients, livestock feed, soil organic matter and energy.

http://www.cog.ca/documents/Economics%20of%20organic%20farming.pdf

Indigenous Crops with Diversity

- Traditional and indigenous crops are highly adapted and resilient to local conditions (including microclimate, soil, pests etc.) over hundreds or even thousands of yrs.
- Require minimal inputs. Can be very successfully grown using organic methods and without mechanization.
- Reduce the farmer's need to borrow: own seed, own manure, no pesticide etc…beats the debt-trap.
- Premium market price…due to better quality and organic certification.
- Increasing crop diversity on farm, improves resilience to weather fluctuations in rainfall, weather conditions, pest attack etc; prevents a total crop failure—inherent insurance policy

Indigenous Crops with Diversity

- Improve farmers' diets.
- Occupy an ecological niche and minimizes environmental impacts incl. soil degradation, water wastage, habitat destruction, pollution, etc.
- Encourage seed saving: dynamic seed banks—diverse gene pool of successful adaptations to local conditions.
- Encourage local agribusiness such as processing and preservation of traditional foods.
- This provides local food security (during off season), community income and reduces dependence on large commercial agricultural companies that can be exploitative to small farmers.

Questions About Alternative/ Organic Farming

- Can alternative farming produce enough food for everybody?
- Is it economically feasible?
- Is it possible to meet the nutrient requirements of crops entirely from organic sources?
- Are there any significant environmental benefits of alternative farming?
- Is the food produced by organic/alternative farming superior in quality?
- Is it possible to manage, weeds, pests and diseases in alternative farming?

Viable Option for Future Food Security

- Neither conventional, nor organic/alternative agriculture might be sufficient to provide for future food needs due to enormous projected growth in population.
- Yet, modeling studies indicate that large-scale conversion to organic agriculture would neither result in drastic reduction in world food supplies nor necessitate conversion of undisturbed lands to agriculture.
- In fact, widespread conversion to organic agriculture would result in crop yield increases as a result of increased investment in research and extension.

Avery, D. T., Saving the planet with pesticides and plastic: The environmental triumph of high-yield farming. Hudson Institute, Indianapolis, 1995, p. 432.
Trewavas, A. J., The population/biodiversity paradox. Agricultural efficiency to save wilderness. *Plant Physiol., 2001,* ***125, 174–179.***
Lampkin, N. H., Estimating the impact of widespread conversion to organic farming on land use and physical output in the United Kindom. In *Economics of Organic Farming (eds Lampkin, N. H.* and Padel, S.), CAB, Wallingford, UK, 1994, pp. 353–359.

Viable Option for Future Food Security

- Limiting population drastically is a matter of necessity
- Equitable food distribution is also required.
- Prevention of diversion of foodgrains towards livestock feed must be prevented…a case for vegetarianism.
- Prevention of conversion of agricultural lands (or produce) into fuel farms must be prevented.
- If the above critical issues are successfully addressed, organic agriculture is an economically viable, environmentally friendly and socially nurturing option.

Organic Farming Yields

- Avg. yield increases due to organic farming—A survey of 208 projects in developing tropical countries:
  - 5–10% in irrigated crops and
  - 50–100% in rainfed crops
- Significantly higher yields than conventional when under stress caused by drought, heat, excessive rain or unseasonably cold weather, disease or pest attack.
- 30% reduced yields in transitional phase (1-4 yrs.) depending upon intensity of mechanization and chemical use prior to switchover. Yields recover after transitional period.
- Premium prices after transitional phase.
- Steady annual growth in demand (20-25%) for organic food in developed and developing countries.

Pretty, J. and Hine, R., Reducing food poverty with sustainable agriculture: A summary of new evidence. SAFE Research Project, University of Essex, Wivenhoe Park, UK, 2001, p. 136. http://www.ias.ac.in/currsci/feb252005/561.pdf
http://www.cog.ca/documents/Economics%20of%20organic%20farming.pdf

Do Polycultures Overyield Monocultures?

- Overyield in polycultures is common.
- The traditional corn/beans/squash polyculture of Mexico produces overyields as high as 50 %
- Some studies found overyields as high as 150 %
- Another study: consistent 5-15% increase in yields due to intercropping
- Perennial polyculture: The Land Institute
  - 19% overyield with a mixture of eastern gamagrass and Illinois bundleflower,
  - 26% overyield with 3-species mixture (eastern gamagrass, Illinois bundleflower, and the cool season (C3) mammoth wild rye.

S. R. Gliessman, “Sustainable Agriculture: An Agroecological Perspective,” in John Andrews and Inez Tommerup, eds., *Advances in Plant Pathology, Vol. 11, Academic Press, London, 1995, pp. 45–57 (referenced in Geno* and Geno, 2001).

M. Liebman, “Polyculture Cropping Systems,” in *Agroecology: The Science of Sustainable Agriculture, M. A.* Altieri, ed., Intermediate Technology Publications, London, 1995, pp. 205–218 (referenced in Geno and Geno, 2001).

R. W. Snaydon and P. M. Harris, “Interactions Below Ground—The Use of Nutrients and Water,” in *Proceedings of the International Workshop on Intercropping, R. Willey, ed., International Crops Research Institute for* the Semi-Arid Tropics, Patancheru, Andhra Pradesh, India, 1981, pp. 188–201 (referenced in Geno and Geno, 2001).

Low Inputs and Sustainable Productivity

- Organic farm production costs < conventional farms, with low purchased inputs.
- Inputs eliminated or drastically reduced are: fertilizers, pesticides, purchased feed, veterinary bills, and replacement livestock
- Organic farmers have lower fixed (overhead) costs for depreciation and interest charges attached to capital inputs, such as machinery and equipment.
- Enrichment of soil ensures future (sustainable) productivity.
- No increase in tillage needs for weed control upon following good management practices and improving soil structure.

Economic Feasibility of Organic Agriculture

Organic Farming is certainly economically feasible due to the following reasons:

- High or ‘at par’ yields
- Low inputs
- Better storage quality of products
- Premium prices and growing demand
- Farm self-sufficiency
- Increased resilience and high productivity under adverse conditions
- Sustainable use of local resources
- Empowerment of farmers and local communities.

Economic Feasibility of Organic Agriculture

High Profits!!

Good returns due to premium prices and comparable yields

Low inputs. Local inputs of manure etc.

Profit = (total returns) - (total costs or inputs)

Economic Feasibility: Testimony from Cotton Farming

The economic study of organic cotton cultivation compared to conventional cotton cultivation in India, over a period of 6 yrs.:

- Reduction in cost of cultivation
- Increased gross and net returns

Rajendran, T. P., Venugopalan, M. V. and Tarhalkar, P. P., Organic cotton farming in India. Central Institute of Cotton Research, Technical Bulletin No. 1/2000, Nagpur, 2000, p. 39.

Organic Foods Retain Quality Better

- Organic products retain post-storage quality better than conventional products.
- Can fetch a better market price after storage
- Reduced spoilage during storage.

Reganold, J. P., Glover, J. D., Andrews, P. K. and Hinman, H. R., Sustainability of three apple production systems. *Nature, 2001,* **410, 926–930.**
Benge, J. R., Banks, N. H., Tillman, R. and De Silva, H. N., Pairwise comparison of the storage potential of kiwi fruit from organic and conventional production systems. *N. Z. J. Crop Hortic. Sci.,* 2000, **28, 147–152.**

Organic food: Safe and Healthful

- Studies reject the claim that organic foods increase exposure to microbiological contaminants
- Organic foods are proved superior in terms of health and safety

Pell, A. N., Manure and microbes: Public and animal health problem? *J. Dairy Sci., 1997,* ***80, 2673–2681.***
Burros, M., Anti-organic and flawed. *New York Times, 17 February* 1999.
Jones, D. L., Potential health risks associated with the persistence of *Escherichia coli O157 in agricultural environments. Soil Use Manage., 1999,* ***15, 76–83.***
Rutenberg, J., Report on organic foods challenged. *New York Times, 31 July 2000, p. C 11.*

Organic food: Safe and Healthful

- Higher levels of vitamin C and essential minerals such as calcium, magnesium, iron, and chromium—The UK Soil Association..
- An independent study found higher levels of all 21 nutrients in organic crops, particularly potatoes, cabbage, spinach and lettuce.
- Higher micronutrient content that contributes to better health
- Consumers have lower incidence of non-communicable diseases and boosts plant and animal immunity against disease
- Up to 50% fewer mycotoxins (toxins produced by fungi)

http://www.i-sis.org.uk/FAOPromotesOrganicAgriculture.php

Organic food: Safe and Healthful

- Organic products have significantly lower pesticide residues than conventional products.
- Significantly lower nitrates in organic foods (nitrates are associated with intensive use of nitrogen fertilizers) are significant food contaminants

FAO, Food safety and quality as affected by organic farming. Agenda item 10.1. In Twenty-Second FAO Regional Conference for Europe, Porto, Portugal, Food and Agriculture Organization of the United Nations, 24–28 July 2000.

Woese, K., Lange, D., Boess, C. and Bogl, K. W., A comparison of organically and conventionally grown foods – Results of a review of the relevant literature. *J. Sci. Food Agric., 1997,* ***74, 281–293.***

Benbrook, C. and Baker, B., Placing pesticide residues and risk in perspective: Data-driven approaches for comparative analyses of organic, conventional and IPM-grown food. In *Ecological Farming Conference, Monterey, CA, 24–27 January 2001, www.eco-farm.org.*

Successful Pest Management

- Preventative pest and disease management strategies are successful
- Involves selection of hardy crops and varieties.
- Improving soil and plant nutrients to grow healthy plants that are resistant to disease and pests.
- Use of 'organic' pesticides e.g. neem products.
- Biological pest control: encourage natural predators like spiders, wasps, frogs, lizards, birds by providing suitable habitats.
- Timing planting, harvest and watering, etc.
- Pest and disease incidence is less severe in organic farms.

Organic: Environment Friendly

- Organic farming systems (compared to conventional farming) performed significantly better on 18 environmental impact indicators and worse in none.
  - A review of over 300 published reports
  - Environmental impact indicators (floral diversity, faunal diversity, habitat diversity, landscape, soil organic matter, soil biological activity, soil structure, soil erosion, nitrate leaching, pesticide residues, CO_2, N_2O, CH_4, NH_3, nutrient use, water use and energy use), organic farming systems performed significantly better in 12 and performed worse in none.

Stolze, M., Piorr, A., Haring, A. and Dabbert, S., The environmental impact of organic farming in Europe. In *Organic Farming in Europe: Economics and Policy, University of Hohenheim, Hohenheim,* Germany, 2000.

Organic Input Availability

- Application of organic manure is the only option to improve the soil organic carbon for sustenance of soil quality and future agricultural productivity.
- Theoretically 700 mt of agricultural waste in India/yr. for conversion to manure.

	Theoretical Availability	Estimated Actual Availability
Manure basis tonnes /ha arable land/yr	5	1.5
NPK basis Kg/ha arable land/yr	100	33

Katyal, J. C., Organic matter maintenance: Mainstay of soil quality. *J. Indian Soc. Soil Sci., 2000,* ***48, 704–716.***
72. Tandon, H. L. S., In *Plant Nutrient Needs, Efficiency and Policy Issues: 2000–2025, National Academy of Agricultural Sciences,* New Delhi, 1997, pp. 15–28.

Sequestering Carbon Benefits Agriculture

- Adding 1 ton C/ha to degraded soil can increase crop yield by 20-40 kg/ha for wheat, 10-20 kg/ha for maize, and 0.5-1 kg/ha for cowpeas.
- Can offset fossil fuel emissions by 0.4-1.2 gigatons C/yr…5-15% of the global fossil-fuel emissions.
- Soil C can be improved by afforestation, agroforestry, no-till farming, cover crops, manuring and sludge application, improved grazing, water conservation and harvesting, efficient irrigation, avoiding water logging.
- Soils under conservation tillage contain 30–50% more C than soils under traditional tillage (Nelson, 1999).

http://www.sciencemag.org/cgi/content/abstract/304/5677/1623

Sequestering Carbon Benefits Agriculture

- Regenerative agriculture (no-till, mulching, cover cropping, manuring, biochar) if practiced on the planet's 3.5 bi. tillable acres, could sequester up to 40% of current CO_2 emissions—agricultural carbon sequestration.
- At a C-sequestration rate of 2,000 lb/ac/year (over 1,760,000 km^2) of USA's cropland could sequester 25 % (1.6 bi. tons) of USA's total fossil C-emissions (6.5 bi. tons)
- The same practices can dramatically enhance yields (by 50-100%) on rain-fed or drought prone lands.
- Organically managed soils can thus convert CO_2 from a greenhouse gas into a food-producing asset.

http://en.wikipedia.org/wiki/Carbon_sink
^ A report recently released by Rodale Institute and based on nearly 30 years of research in its side-by-side studies of organic and conventional agriculture. ^ Lappé, Anna (9 May 2008). "Timothy LaSalle of Rodale on the surprising climate benefits of organic farming". *Grist*. http://www.grist.org/feature/2008/05/09/index.html?source=rss.

Organic Agriculture: Human Friendly

- Organic agriculture, can integrate tradition, new knowledge and innovation
- It can lead to an increased engagement in farming
- It can trigger greater opportunities for rural employment and socio-economic upliftment.
- Positive health impacts
- Local food security and nutrition
- Empowerment of farmers and local communities.

Watch Video: Farming - The Gandhian Way - A Tribute to Shri. BHASKAR SAVE (12 min)

Agriculture: The Natural Paradigm

- Natural ecosystems are self-supporting.
- They do not require external inputs other than rainwater, sunlight etc.
- They lead to an improvement in fertility and productivity over time.
- Can we design agricultural systems on the lines of natural ecosystems?
- **Nearly, self-supporting...requiring minimal inputs...and yet highly productive**

Food Forests and Agroecosystems

- Geoff Lawton's: 7 Food Forests in 7 minutes (7 min)
- 300 Year Old Food Forest in Vietnam (6 min)
- Padma Shri Subhash Palekar's Zero Budget Natural Farming in India - How it can transform Agriculture in - Current Affairs 2018 (16 min) - Hindi
- Kailash Murthy and Natural Farming (13 min)

Superiority of the Natural Paradigm

Very High Efficiency!!

- High yields.
- Overyielding polycultures

$$\text{Efficiency} = \frac{\text{Output}}{\text{Inputs}}$$

Low inputs of:

- manure
- labor
- machinery
- irrigation, etc.

Meet The Grandfather of Natural Farming...

Masanobu Fukuoka

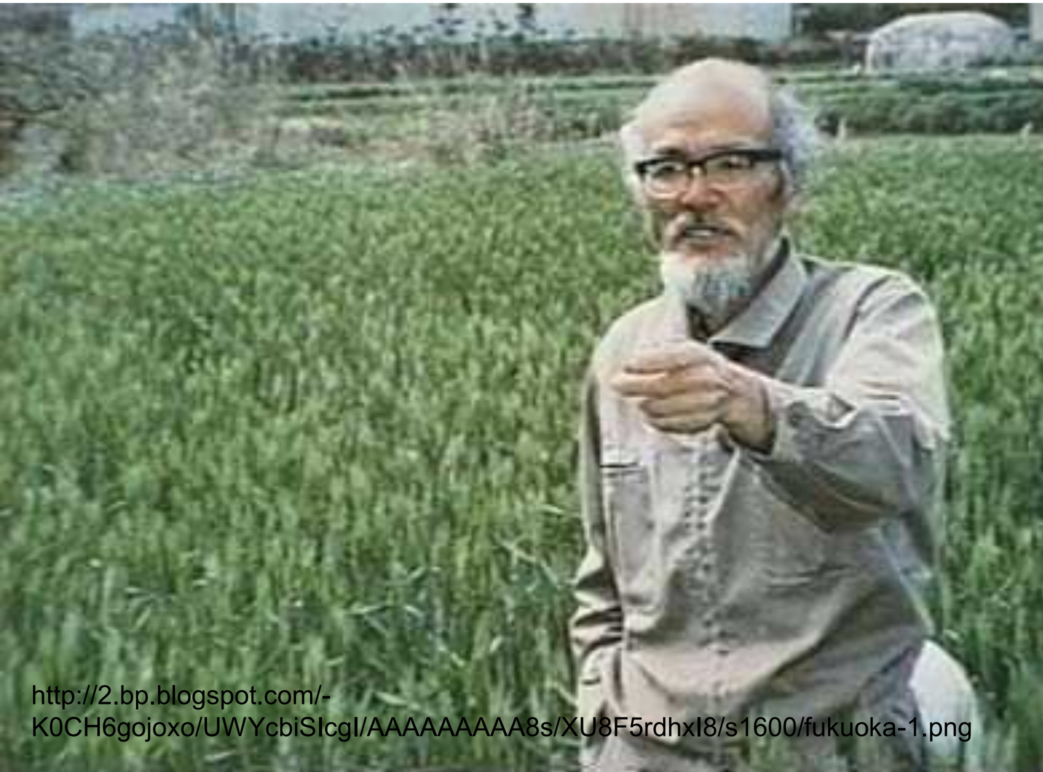
- Agricultural scientist, farmer, philosopher, admirer of Gandhi.
- Awards: Ramon Magsaysay Award, Desikottam Award, Earth Council Award
- Author of: " The One-Straw Revolution" By Masanobu Fukuoka (and 3 other titles)
  - No-till, no fertilizer, no pesticide, ground mulch and green cover, direct seeding (seed balls)

Watch Videos:

- **One Straw Revolution - by Masanobu Fukuoka (24.38)**
- **How to do Masanobu Fukuoka's natural farming. (13.28)**
- **Masanobu Fukuoka rice and orchard techniques (5.35)**

Masanobu Fukuoka (1913-2008)

https://en.wikipedia.org/wiki/Masanobu_Fukuoka



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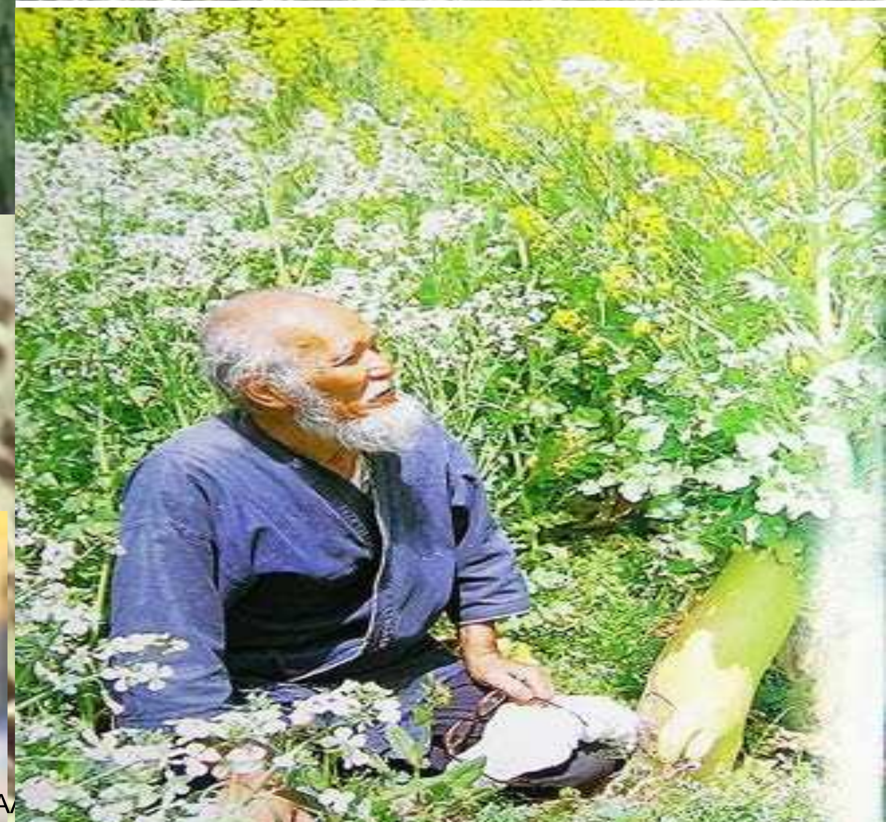


http://www.vidaenlatierra.com/images/latest-projects/Masanobu-Fukuoka.jpg

Outline

- Dimensions of the Food Crisis
  - Hunger, poverty, production, distribution
- Threats to Food Security: Present and Future
- Solutions to the Food Crisis
  - Theoretical (Present) Solution
    - Food Distribution
  - Real Solutions
    - Industrial Agriculture?
    - Alternative Agriculture
    - **Vegetarianism**
    - What Can You Do?

Vegetarianism and Sustainability

Dr R. K. Pachauri, Chairman of IPCC: “We didn’t say it before, but we are saying it now. One of the best ways to fight global warming is to adopt a vegetarian diet”. Speech in Geneva, January 15, 2008

A Crowded Earth

- World meat production has surged nearly 5-fold between 1950—1997 (44 → 211 million tons)
- The world fish harvest surged 6-fold between 1950-2000 (21 → 120 mi. tons)…per capita consumption tripled.
- Per capita meat production stands at 36 kg (> 2x of 1950 level)
- ~6 bi. humans share the Earth's natural resources with nearly 1 bi. pigs, 1.3 bi. cows, 1.8 bi. sheep and goats, and 13.5 bi. chickens. (~ 3 heads of livestock/ person)

World's Livestock Population Growth

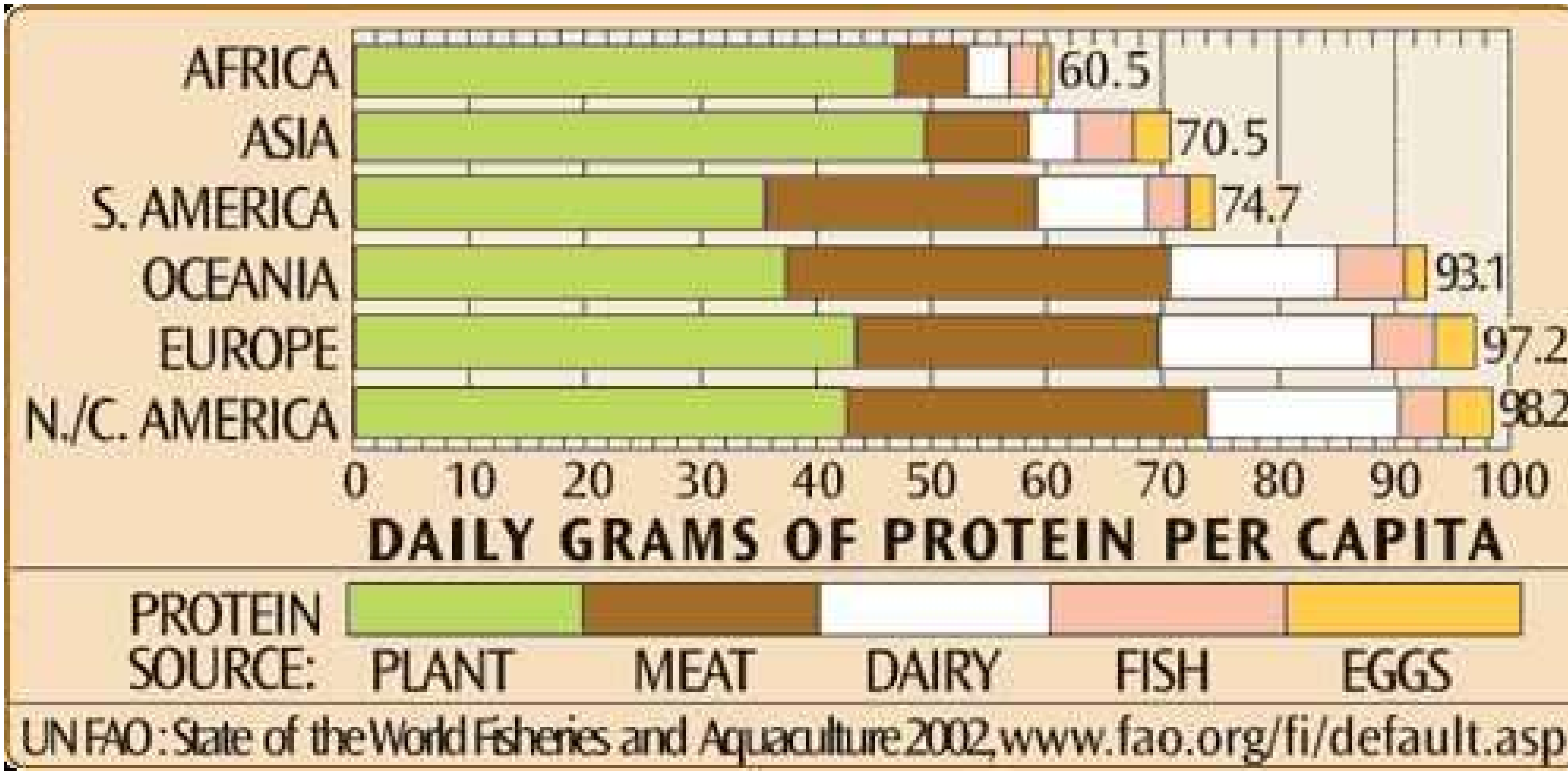
Livestock	1960	1997	Increase
	(billion)	(billion)	(percent)
Cattle	0.94	1.33	42
Sheep and Goats	1.34	1.77	32
Pigs	0.41	0.94	131
Chickens	3.90	13.41	244
Humans	3.08	5.85	90

Source: UN Food and Agriculture Organization, FAOStats, 21 June 1998.

Country-wise Meat Consumption

Country (kg meat/person/yr)	Beef	Pork	Poultry	Mutton	Total
United States	44	31	48	1	123
Germany	16	54	15	1	86
Italy	26	35	19	2	82
United Kingdom	16	25	27	6	74
Brazil	36	9	24	-	70
New Zealand	37	-	-	29	66
China	5	35	11	2	53
Russia	19	13	13	1	46
Japan	12	17	12	1	40
Egypt	8	-	6	1	16
India	1	-	1	1	3
Indonesia	-	-	2	-	2
All Industrial Nations	21	25	24	2	72
All Developing Nations	5	11	7	1	24

Per Capita Protein Intake: Sources



- "10 kcalories (kilogram-calories or 'large calories') of exosomatic energy are spent in the U.S. food system per calorie of food eaten by the consumer. Put another way, the (US) food system consumes ten times more energy than it provides to society in food energy."

Meat Eating and Health Problems

- The avg. American consumes nearly twice his or her weight in meat each year.
- High growth in consumption of meat (esp. high-fat meat), dairy products and eggs—more cholesterol, saturated fat, and protein.
- Global epidemic of lifestyle diseases: heart attacks, strokes and cancers.
- Chinese government to limit the country's meat consumption: to avoid massive health care costs (100s of bi. of USD)

https://www.worldwatch.org/node/1626

In China a recent shift to meat-heavy diets has been linked to increases in obesity, cardiovascular disease, breast cancer and colorectal cancer.

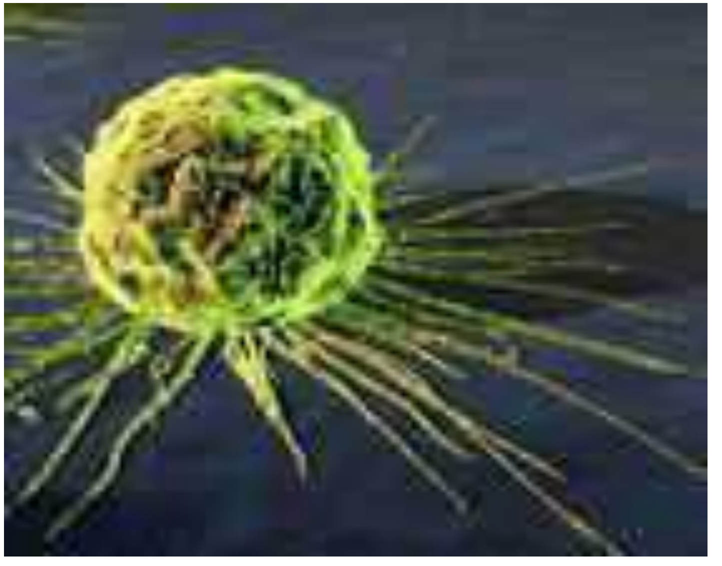
Superiority of Plant Protein

- Professor Colin Campbell: “There is a mountain of compelling evidence that so called “low quality” plant protein which allows for slow but steady synthesis of new proteins is the *healthiest* type of protein”

“Heart Attack Proof” Diet

- Diets of Dr. Dean Ornish and Dr. Caldwell Esselstyn keep cholesterol levels below 150, the level below which no one has ever suffered a heart attack.

At the turn of the century, heart disease and cancer used to cause 8% and 4% of deaths.



Now they cause 36% and 22% of deaths.

"The vast majority, perhaps 80 percent to 90 percent, of all cancers, cardiovascular diseases, and other forms of degenerative illness can be prevented, at least until very old age, simply by adopting a plant-based diet."

Dr. T. Colin Campbell
Cornell University

Healthy Human Diet

- For infants: mother’s milk.
- For adults: fruits, vegetables and whole grains, pulses, nuts .

Das Bild kann zurzeit nicht angezeigt werden.

Barry A. Popkin, Scientific American, June, 2008

Meat Eating—A Net Drain on Economy?

- Conservative estimate: excessive meat consumption linked to health care costs of $60—120 bi./yr in USA.
- Domestic cash receipts for the meat industry totaled roughly $100 billion in 1997.
- It is possible that this industry is a net drain on the American economy.

…Dr. Colin Campbell of Cornell University

Starvation Deaths

- 1 person dies every second directly or indirectly due to hunger…4000/hr…100,000/day…36 mi. /yr
- 58 % of all deaths are due to hunger (2001-2004 estimates)
- 1 child dies every 5 seconds directly or indirectly due to hunger…700/hr…16,000/day…6 mi./yr.
- 60% of all child deaths are due to hunger (2002-2008 estimates)

http://en.wikipedia.org/wiki/Starvation

Saving Grain for the Hungry

- The world already produces enough food for the present 7 billion people; could even support double — 12 billion people.
- But 36 % of world's grain (21% in developing countries and 70% in industrial nations) feeds livestock, poultry, and fish farms…inefficient converters of grain
- 1 kg meat ➔ ~7 kg of grain (corn or wheat)…human food!
- 670 mi. tons of the world's grain used for feed could feed 800 mi. people.
- In 2007, 923 mi. undernourished.

Saving Grain for the Hungry

- 10% of this feed (67 mi. tons of grain) could sustain 225 mi. people or keep up with world population growth for the next three years.
- If each American reduced his meat consumption by only 5 %, (1 dish less/week); the 7.5 mi. tons of grain saved, could feed all the 25 mi. people going hungry in the US each day.

Inefficiency of Protein Production

USA:

- 7 bi. livestock heads consume 5x grain consumed by the entire American population.
- 41 mi. tons/yr of plant protein is fed to U.S. livestock to produce 7 mi. tons of animal protein for human consumption.
- 26 mi. tons of the livestock feed comes from grains and 15 mi. tons from forage crops.
- 1 kg of high-quality animal protein produced, consumes 6 kg of plant protein.

Energy

- In the USA, 20 times as much energy is required to produce one calorie of animal food as is required to produce one calorie of vegetable food

Energy Consumption

	(Fuel input): (Protein produced)
Chicken	4:1
Beef	54:1
Lamb	50:1
Turkey	13:1
Pork	17:1
Eggs	26:1
Milk	14:1
Grains	3.3:1*

(Fossil Fuel input Kcal): Protein produced Kcal)

* Figure pertains to grain farming by conventional methods. This can be made drastically more efficient by using natural farming methods.

http://www.news.cornell.edu/releases/Aug97/livestock.hrs.html

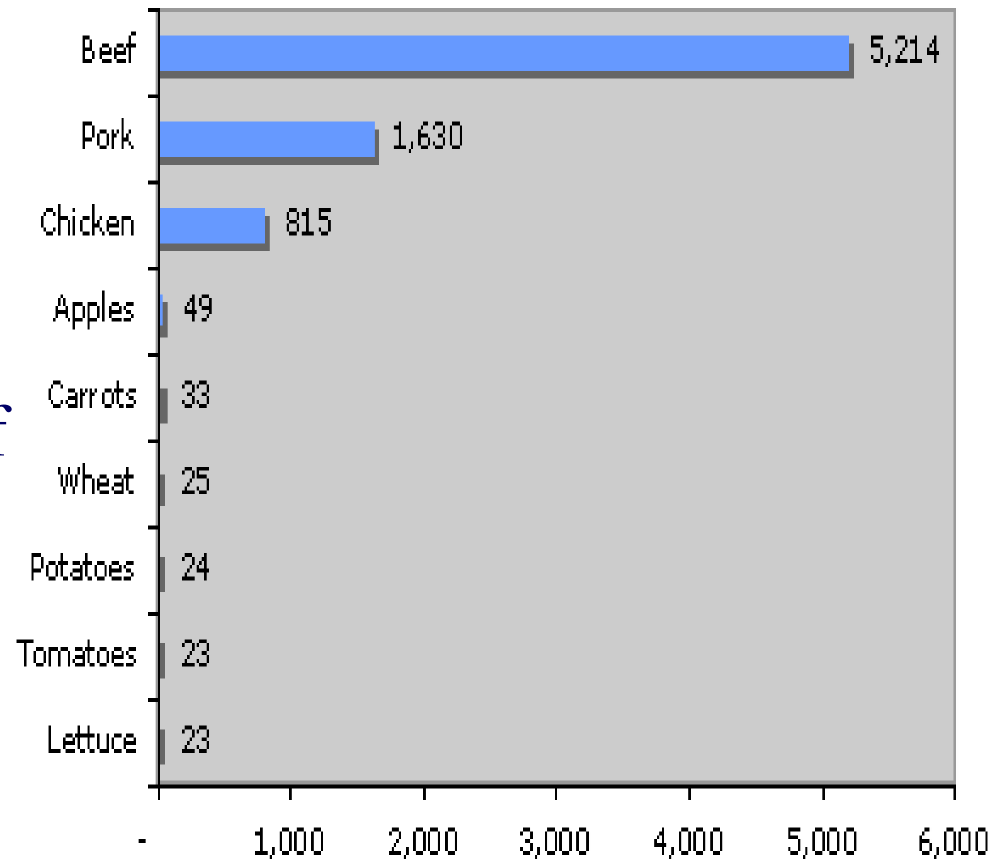
Contribution to Global Climate Change

- World's livestock production is the largest source of anthropogenic methane emissions…EPA
- Livestock herds account for ~ 25 % of anthropogenic emissions of methane…climate change.
- Stagnant waste lagoons of factory-farm operations emit an additional 5 % percent of human-induced methane.

Water Use

- U.S. agriculture accounts for 87 % of all the fresh water consumed each year.
- Livestock direct use 1.3 %
- Livestock total use ~ 50 % (incl. forage and grain production for livestock)
- 1 kg beef takes 100 tons of water
- 1kg wheat takes 0.9 tons of water
- 1 kg potatoes 0.5 tons of water

Gallons of water to produce 1 lb of various foods (236)



Water

- To produce 1 lb. of feedlot beef requires 7 lbs. of feed grain, which takes 7,000 lbs. of water to grow.

One half of all US water resources are used to grow meat.

Pass up one hamburger, and you'll save as much water as you save by taking 40 showers with a low-flow nozzle.

1  = 40 

Meat eaters require 14 times as much water for their diets as do vegetarians.

Water Pollution

- For example, shifting from pork to chicken requires half the grain, and hence half as much water.
- The massive quantities of waste produced by livestock and poultry threaten rivers, lakes and other waterways with pollution, toxic algal blooms and massive fishkills.
- US livestock waste is 130 times that produced by humans. ,
- Livestock farms are getting larger throughout the world.

Water Pollution

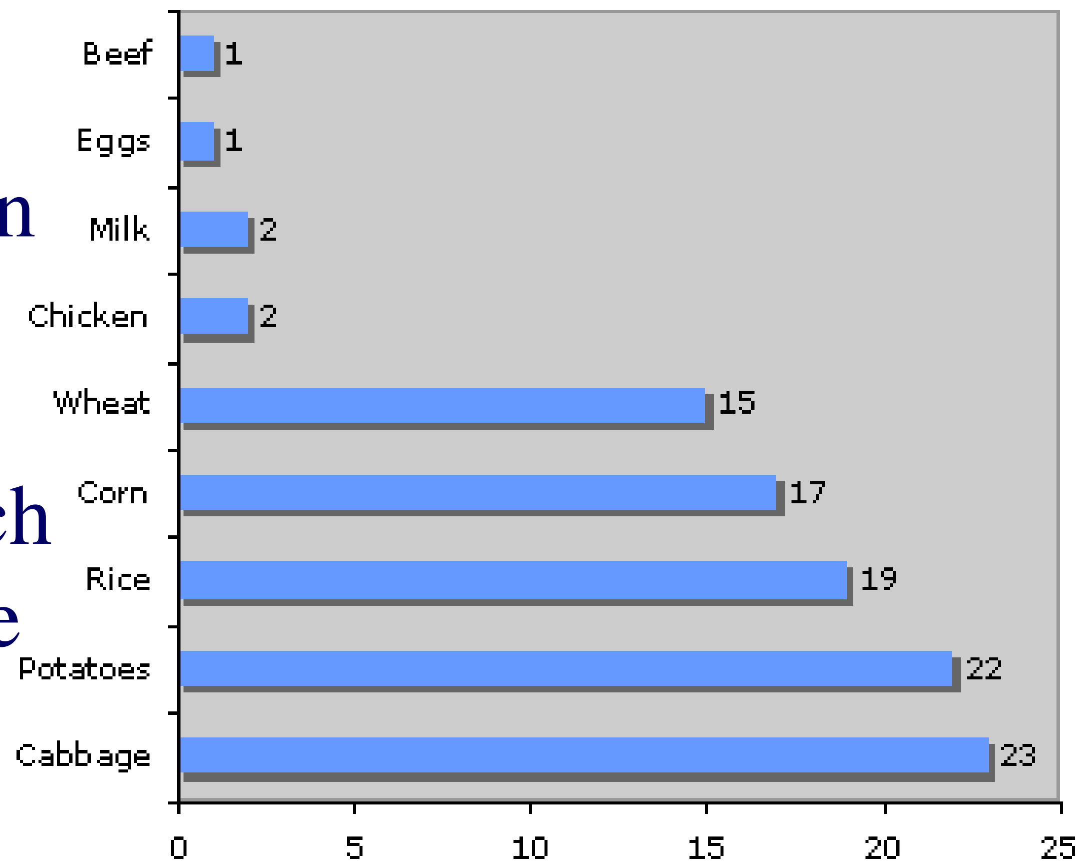
- According to the Environmental Protection Agency, factory farming pollutes U.S. waterways more than ***all*** industrial sources combined.

In the U.S., livestock now produce ***130 times*** as much waste as people do. Just one 50,000 acre hog farm in Utah, for example, produces more sewage than the city of Los Angeles!!

Land

- According to scientists at the Smithsonian Institute, the equivalent of seven football fields of land is bulldozed every minute, much of it to create more room for farmed animals.

Number of people whose caloric needs can be met on 2.5 acres of land for the following foods (294)



80% of all US agricultural is used in some way to raise animals—that's roughly half of the total land mass of the U.S.

Diet and Land Requirement

S. No.	Diet	Area (sq. yards)/capita	Population that can be supported by Earth. (multiples of 1985 population of ~5 bi.)
1.	Grains	200	60
2.	Potatoes	600	20
3.	Milk	1500	8
4.	Pork	4000	3
5.	Beef	10000	1

Masanabu Fukuoka (translated by Frederic P. Metreaud) “The Natural Way of Farming – The Theory and Practice of Green Philosophy” 1985 Japan Publications Inc. ISBN 0-87040-613-2.

Forest

- Of the Amazonian rain forest cleared in South America, more than 38 percent has been used for ranching.

More than 260 million acres of U.S. forest have been cleared to create cropland to grow grain to feed farmed animals.

Soil

- "85% of topsoil erosion (wind and water) in USA is due to raising animals for food" …Howard Lyman (American Mad Cow Activist)…
- This is 13 times above the sustainable rate.
- >302 mi. ha devoted to producing feed for the U.S. livestock population (272 mi. ha pasture and 30 mi. ha. cultivated feed grains)
- Iowa: Topsoil loss at 30x soil formation rate. Lost 50% of topsoil in just 150 years of farming—soil that took thousands of years to form.

Animal Slaughter and Torture Before Being Killed

- Every year, nearly ***9 billion animals*** are killed for food in the United States alone!!
- Video: Can you Face the Reality of Factory Farming? (6.08min)
- Video: Meet Your Meat (12.48)
- Whether animals are raised in factory farms, or in open farms, the slaughter, the pain, the suffering and death are common and inevitable.

Food, Spirituality and Humanity

- When plentiful vegetarian food is available.
- Yet, humans insist on consuming non-vegetarian food.
- It is simply for the sake of one's tongue.
- This is needless "himsa" (unjustified violence).
- The highest Dharma (righteousness) is refraining from unjustified violence (ahimsa).
- Do we not have any sympathy for the sorrow and suffering of other living beings?

Vegetarianism and Spirituality

- The dying animal says "As this person (*saḥ*) is killing and consuming me (*mām*) in this lifetime, so shall I kill and consume him in my next lifetime." This is real meaning of the word 'māmsa*ḥ*' (meat) as explained by the wise ones. --Sh*ā*stras
- The butcher kills for the sake of those who buy and consume the meat.
- All are fellow-conspirators in the killing.
- As per the law of karma, every action has an equal and opposite reaction. It is inevitable.
- So all of them face the same end in their next birth.

Reducing Meat: Win-Win Situation

- Massive reductions in meat consumption in industrial nations will ease the healthcare burden while improving public health
- Declining livestock herds will take pressure off of rangelands and grainlands, allowing the agricultural resource base to rejuvenate.
- Lowering meat consumption worldwide will allow more efficient use of land and water resources. Relevant for increasing population.
- Make grain more affordable to the world's chronically hungry.
- **Humanity becomes more human!**

Food Crisis: What can you do?

- Avoid MNC-marketed hybridized/GM crops and products.
- Eat home-cooked, fresh food; avoid preserved, processed or junk food.
- Be vegetarian: Spare the grain for hungry humans. Have a heart! "Don't turn your stomach into a graveyard for unfortunate dead animals!"—Lokmanya Tilak
- Farmer microfinancing options
- Local community-operated warehousing, cold storage and food processing/preservation industry for farmers to survive unfair price-fixing, and market crashes.

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- Make grain more affordable to the world's chronically hungry.

“When human beings come to understand that animals also experience pleasure and pain they will acquire a new dimension of wisdom. It is because of our human sense of duty and our higher understanding that we should be sympathetic to all living beings.”

P.R. Sarkar

Outline

- Dimensions of the Food Crisis
  - Hunger, poverty, production, distribution
- Threats to Food Security: Present and Future
- Solutions to the Food Crisis
  - Theoretical (Present) Solution
    - Food Distribution
  - Real Solutions
    - Industrial Agriculture?
    - Alternative Agriculture
    - Vegetarianism
    - **What Can You Do?**

Food Crisis: What can you do?

- Support local produce: local farmers, retailers
- Grow your own food: urban gardens, community gardens/farms, terrace gardens.
- Adopt low input, small-scale, biodiverse, organic/natural farming methods integrated with sustainable land and watershed management.
- Both farmers and consumers should support crop diversity. Plant and purchase delicious and nutritious minor millets, pulses and vegetables.

Food Crisis: What can you do?

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Food Crisis: What can you do?

- Ensure dignity of farmers and workers
- Ensure living wages
- Work for a profound rural change:
  - Land reforms, education, health, infrastructure
- Provide restitution for the injustices of the past and present
- Developed countries to avoid exploitative practices and policies by their govts and MNCs towards poor countries.
- Cancel debts of poorer countries.

Food Crisis: What can you do?

- Enable distribution of surplus food to poor countries
- Fuel plantations must be restricted to marginal lands. Other alternative energy/fuel sources should be researched and promoted.
- Stop war: Promote peace negotiations; resolve issues reg. sharing of scarce resources, religious intolerance and hatred.
- Limit global warming and pollution, land degradation, deforestation, etc.

Reading and Video Resources

- " The One-Straw Revolution" By Masanobu Fukuoka (and 3 other titles)
  - No-till, no fertilizer, no pesticide, ground mulch and green cover, direct seeding (seed balls)
- "Rishi Krishi" By Mohan Shankar Deshpande
  - Angara, earthworms, amritapani, natural pesticides
- "Permaculture" By Bill Mollison
  - Sustainable community, planned designs, natural patterns
  - Food Forests in 7 minutes (7 min) with Geoff Lawton.
  - 300 Year Old Food Forest in Vietnam (6 min) with Geoff Lawton
- Farming - The Gandhian Way - A Tribute to Shri. BHASKAR SAVE
- Nero's Guests by P. Sainath.

Learning is not compulsory…neither is survival.

--W. Edwards Deming

Tackling the growing challenge of soil pollution

"Towards a Pollution-Free Planet"

CPR Meeting

08th January 2019

UNEP, Nairobi, Kenya

Abdelkader Bensada

Ecosystems Division

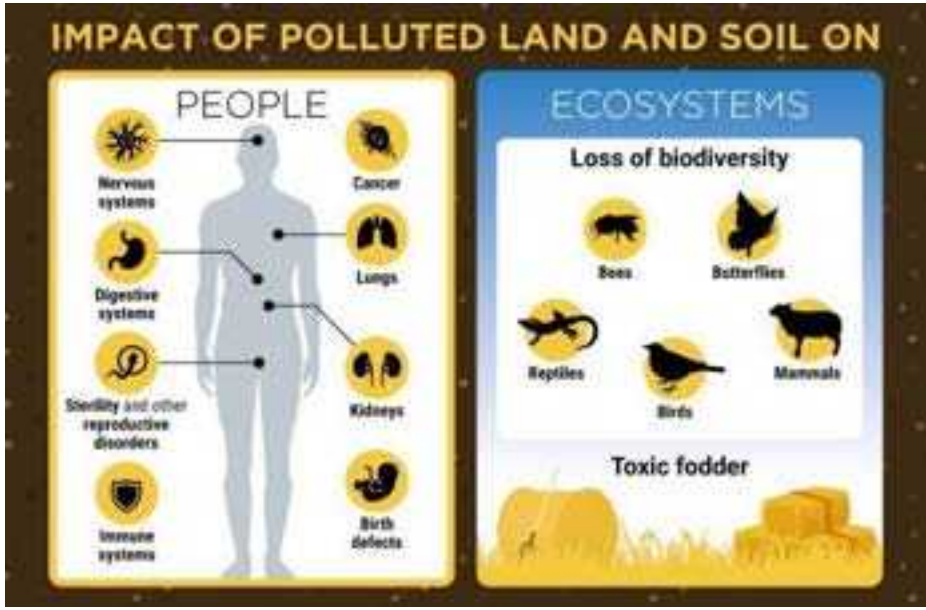
UN Environment

UN environment

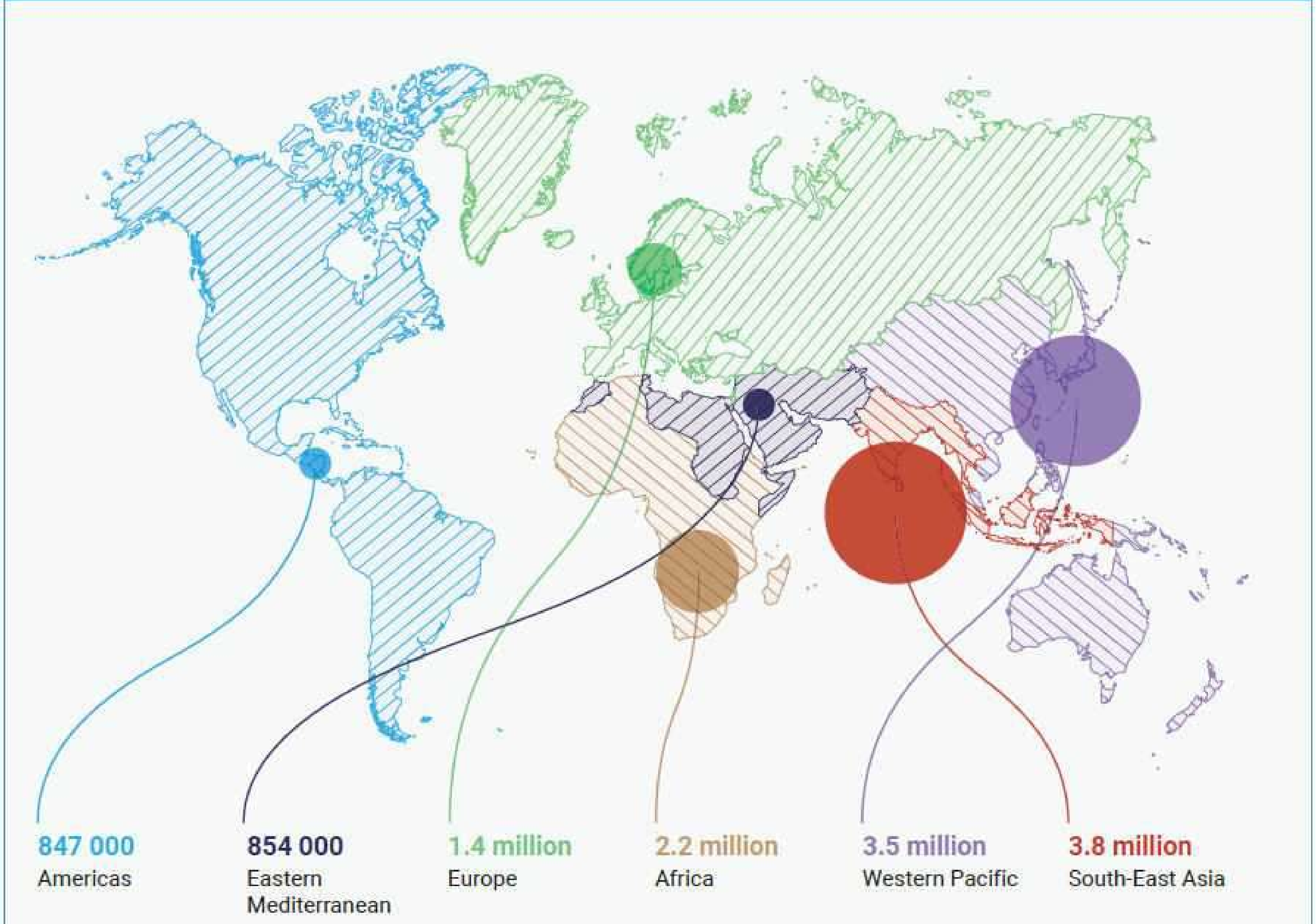
Land/soil (chemicals) pollution

Why does it matter?

- Pollution remains a massive challenge – threatens to intensify as a result of rising consumption, living standards and population growth.
- Pollutants, including human-made chemicals and emissions and domestic and industrial waste streams, are impairing air, water (fresh and marine) and soil quality.
- WHO estimates (2012): 23% of deaths worldwide - 12.6 million people are due to environmental causes
- middle-income countries bear the brunt of pollution-related illnesses, with a disproportionate impact on children.



Number of deaths in 2012 attributable to environmental factors, by World Health Organization region



Pollution challenges
The land/soil pollution perspective

Key concerns:

- Complex pollution leachate mixtures from mismanaged and uncontrolled dumpsites; includes mercury, arsenic, organic compounds, heavy metals and other hazardous substances
- Pesticides and antimicrobial drugs in crop and livestock productions are among pollutants of key concern
- Pollution from abandoned industrial sites, armed conflict zones, nuclear power stations, pesticide stockpiles, waste landfills - part of a longer-term legacy

Framing Action against the UNEA 3/6 Resolution Implementation Plan:

Managing soil pollution to achieve sustainable development

UNEA 3/6 resolution:
Managing soil pollution to achieve sustainable development

OP7: Requests the Executive Director, ..., by UNEA5, to invite, within their respective mandates, relevant United Nations organizations,....:

(a) To prepare a report based on available scientific information and data on:

(i) ... extent and future trends of soil pollution, ...;

(ii) ... risks and impacts of soil pollution on health, the environment and food security, ...

(b) To elaborate technical guidelines for the prevention and minimization of soil contamination ......;

OP8: Requests the United Nations Environment Programme, in consultation with member States, to invite, ...the UNCCD, the WHO, FAO.....other relevant UN entities, in collaboration with partners, ...:

(a) To promote research and development that contributes to controlling and managing soil pollution;

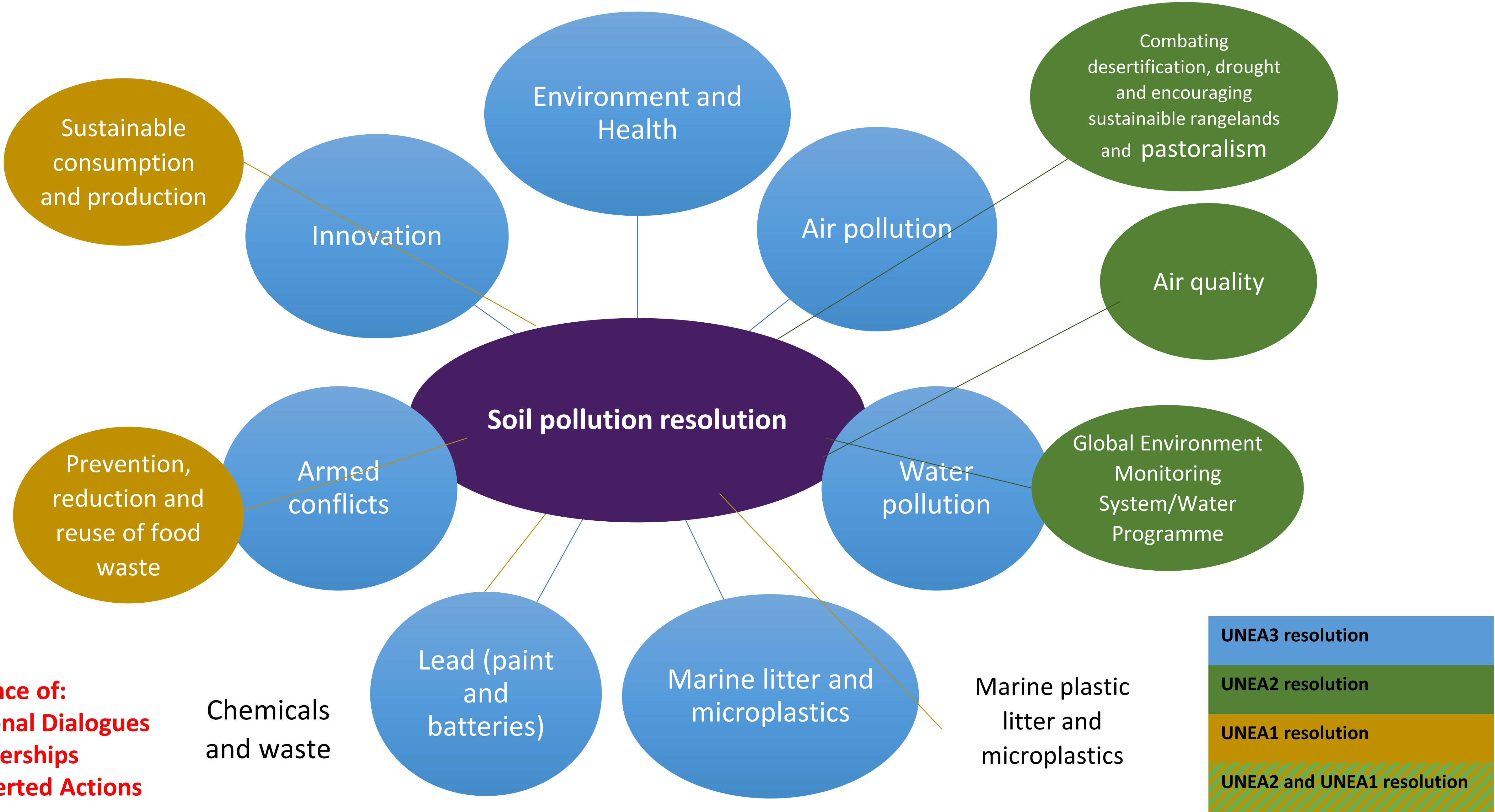
(b) To strengthen the science-policy interface to inform policymaking on soil pollution, ...;

(c) To raise awareness and improve the dissemination of knowledge on soil pollution;

(d) To promote a coordinated approach for combating soil pollution, ...;

OP9: Requests the Executive Director to UNEA4 on progress ......

Soil Pollution-relevant resolutions from UNEA1, 2 and 3



Importance of:
- **Regional Dialogues**
- **Partnerships**
- **Concerted Actions**

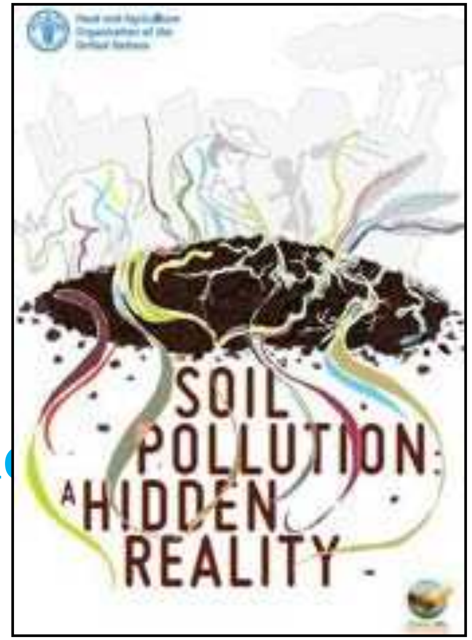
Analysing the UNEA 3/6 resolution to form the building blocks of the implementation plan.

Main categories of activities of Soil Pollution Resolution

✓Science, data, access to information, reporting, SDGs	Standards, regulations and integrated policy development	Industry, private sector engagement, (incl. circular economy/lifecycle) and NGO engagement
Methodologies and tools development, Capacity-building, strengthening of technical and institutional capacity	Education, training	Communication

Regional cooperation, partnership building with all, incl. UN Agencies

International Symposium on Soil Pollution



- It was co-organized between UNEP, FAO, the WHO that was hel Rome at FAO Headquarters in May 2018.
- A side event on the UNEA 3 soil pollution resolution was

convened by UNEP within symposium to present an agenda which suggested way forward.

- The FAO's Intergovernmental Technical Panel on Soils (ITPS) launched the report titled "*Soil Pollution: a hidden reality*". This report is comprehensive and will be a significant input to the UNEA3 resolution.
- The ITPS has agreed to remain engaged in the process and maintain a core role in making technical and scientific contributions, with UNEP facilitating the bridge to the policy reform and mainstreaming with governments and collaborating agencies.

Stakeholders Consultation Workshop

- A consultation workshop to advance implementation of the UNEA pollution resolutions was convened in Paris in June 2018 which was attended by various stakeholder groups, and some Member States through the CPR subcommittee.
- The meeting provided an opportunity for stakeholder input and engagement to shape the UNEA3 Implementation Plan. The meeting assisted to identify and prioritize solutions relevant to the Soil Pollution Resolution.

Coordination & Joint planning

- The Environment and Health UNEP/EA.3/RES.4 resolution being led by the Economy Division has overlap with the Soil Pollution Resolution. The anticipated report under the Environment and Health resolution addresses the impacts of pesticides and fertilizers, and joint planning to harmonize the outputs from the two resolutions is ongoing.

FAO's Joint Meeting on Pesticides Management (JMPM)

Within the scope of the Environment and Health resolution, a First Consultativ Meeting was held in October 2018 back-to-back with FAO's Joint Meeting on Pesticides Management (JMPM).

The meeting brought together subject-area experts on both pesticides and fertilizers to provide clarity on joining the work between the two resolutions.

Implementation Plan and Budget

- A proposal on the broad outline of the UNEA5 Soils Pollution Report has been developed. Against this, a draft implementation plan and budget has been prepared to facilitate resource mobilization. This is being incorporated into a joint mobilization strategy proposal with the FAO for the implementation of the resolution.

- *In September 2018, the Government of France kindly confirmed a grant to UN Environment of Eur 30,000 toward the implementation of the resolution.*

Pollution challenges
The land/soil pollution perspective

Critical gaps

- Implementation gaps: lack of resources; inadequate capacities or political will
- Knowledge gaps: inadequate awareness of key information, insufficient disclosure of information, limited understanding of pollution's social and gender dimensions
- Infrastructure gaps: monitoring and management of wastes; recycling
- Limited leadership - financial institutions and industry: challenges in information disclosure; compliance/due diligence; access to 'green financing'
- Mispricing, invisibility of ecosystems services: treatment of ecosystems as waste dumps and sinks; choices made without awareness of full consequences
- Lack of recognition of consequence of consumer choices: limited understanding of behaviors and incentives; limited empowerment to influence choices, limited information on alternative (affordable options)

Thank you

Land Pollution

By: Maddie, Grace, Alyssa, Deandra, and Dominique

What is Land Pollution?

- **Land pollution is caused by man-made actions.**
- **Land Pollution affects the soil on the Earth.**
- **Also affects the health of humans, animals, and plants.**
- **Land pollution can contribute and help contaminate the air and water.**

(http://www.northampton.gov.uk/images/Image1_9_.jpg)

How's Land Pollution caused?

- Caused by trash and toxic wastes humans leave on the land.
- Lack of recycling which leads to filling up landfills.
- Chemical plants and coal-fired plants cause land pollution.
- Another cause is acid rain and trash that washes ashore from boats and sewage outlets.
- Disposing resources too quickly.

How does land pollution affect us?

- **Land pollution pollutes the environment and our ecosystems.**
- **It causes health problems like birth defects, cancer, and respiratory problems.**
- **It can harm wildlife like plants and animals.**

What if land pollution isn't fixed?

- **Land will become unreliable for life and our agriculture.**
- **Land pollution becomes hazardous to our health.**
- **Landfills and waste dumps increase in size. Which takes up a lot of land and space from wildlife and humans.**

Why may people not want to help stop land pollution?

- **No time or patience to recycle and use organic products.**
- **People argue that preventing this issue is too expensive, impossible, and unimportant.**
- **Land pollution has already escalated to a point where it can't be helped by human beings.**

How do we stop land pollution?

Using the 3 R's:
Reduce, Re-use, and Recycle.

- **Recycle and dispose of trash correctly.**
- **Help clean up the environment by cleaning parks and roads.**
- **Recycle so that the items you recycle can be made into bridges, cars, freezers, and benches.**

How else can we help stop land pollution?

- **With the amount of land pollution we have now, it's very hard to erase.**
- **We can't get rid of the pollution that's already there but we can prevent and control any future land pollution.**

- **Try using products that don't have a lot of packaging to throw away.**

Buy items that are sold in reusable containers and buy biodegradable products.

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Chapter 14 – Noise Pollution and Control

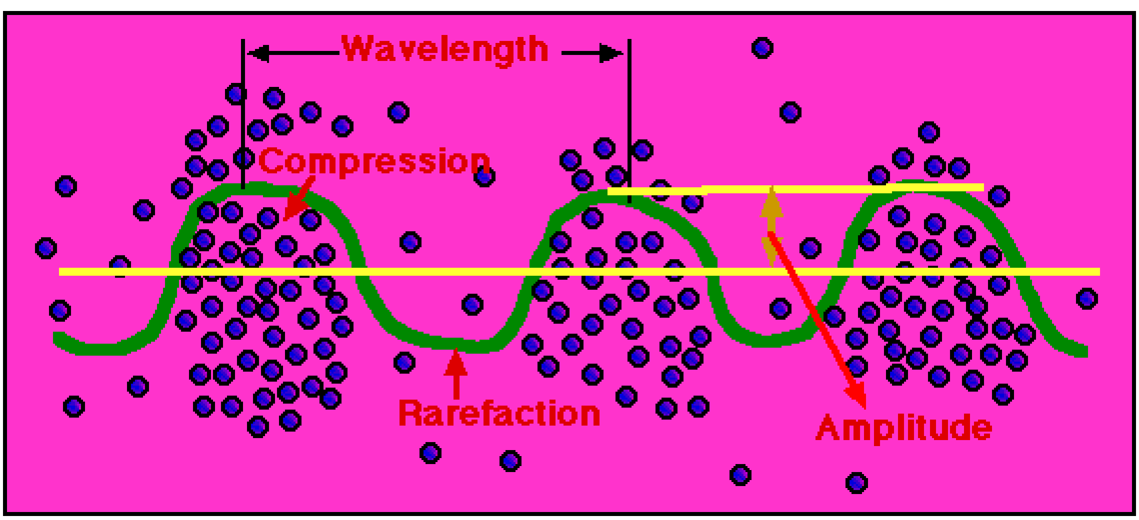
Hwk#7 review questions – pp.472-473 #6,8,15,19
practice prob. – p.474 -#2,7,9,15

•**Noise** – is an undesirable and unwanted sound, and noise is a form of waste energy.
[Note: Not all sound is noise]

•**Sound Waves** - Is the form of transport for sound and it cannot be transmitted in a vacuum due to a lack of medium to carry the vibration.

<u>Chapter 14 – Noise Pollution and Control</u>

- **Wave Lengths-**distance between pressure peaks
- **Frequency** - The number of wavelengths that appear to pass a fixed point in 1 second. [cps or Hz]
- **Amplitude-**heights of the peak which represents the pressure intensity and is related to the volume or loudness.
- **Cycle -** is a single wave length



http://www.umanitoba.ca/faculties/arts/linguistics/russell/138/sec4/acoust1.htm

http://www.fi.edu/fellows/fellow2/apr99/soundvib.html

Chapter 14 – Noise Pollution and Control

• **Speed of Sound-** 1500 m/s in water and 5000 m/s in steel, 340 m/s in air (1100 ft/s).

$$v = \lambda \text{ x f}$$

where, v= speed of sound, m/s or ft/s

λ= wavelength, m/cycle or ft./cycle

f = frequency, Hz or cps

[Note: Speed of sound is constant so the frequency and wavelength is inversely proportional.]

The human ear can detect sounds in the frequency range of about 20 to 20,000 Hz. (The average is 200 - 10,000 Hz)

Sin500.wav

Sin300.wav

Chapter 14 – Noise Pollution and Control

• **microbars-** 1 millionth of a bar, where a bar is equal to 100 kPa or 14.7 psi (atmospheric pressure at sea level)

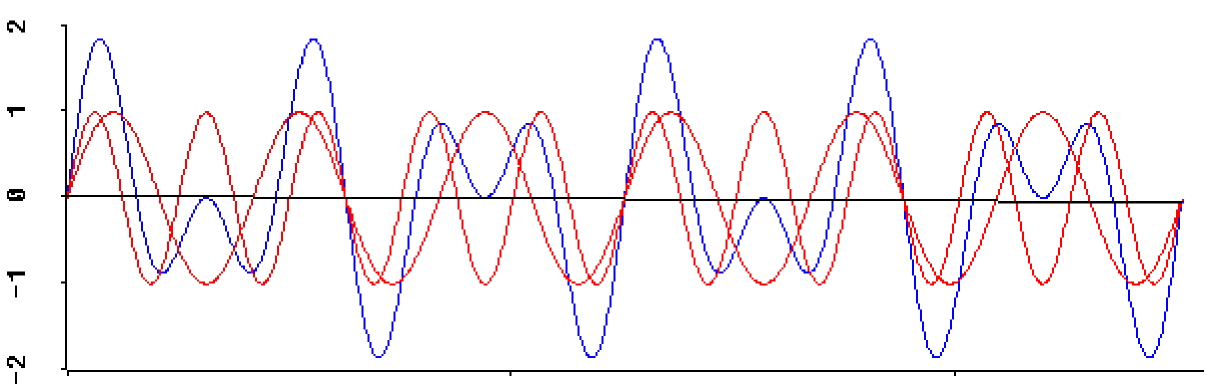
$$SPL = 20 \text{ X } \log\left(\frac{P}{P_0}\right)$$

where, SPL= sound pressure level, dB

P= rms sound pressure, μbar

P_0 = reference pressure, μbar

The reference pressure generally used for Po is the hearing threshold or lowest audible sound pressure of .0002 microbars. (1000 microbars is the highest sound pressure w/o pain)



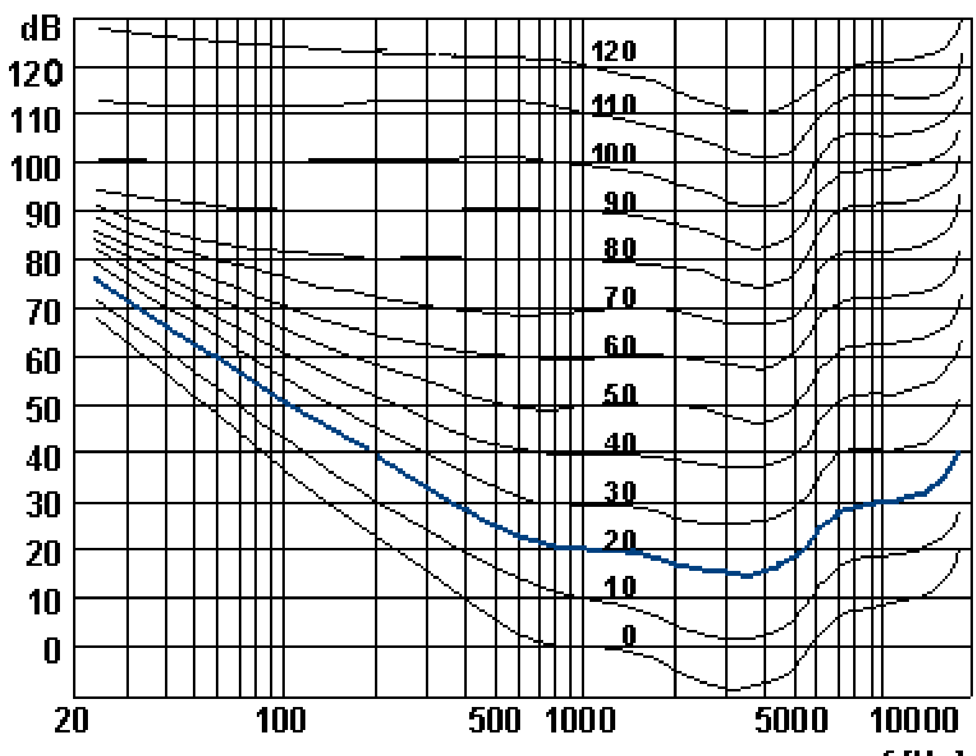
<u>**Chapter 14 – Noise Pollution and Control**</u>

• **decibel scale (dB) -** a ratio of two pressures (Note : 10,000 microbars can cause immediate physical damage.)

•**Sound Pressure Level** - expresses the magnitude of volume or a sound (dB)

[Refer to p.461 in text fig. 14.3]

Note: The avg. person will perceive a high-pitch sound to be louder than a low pitch sound with the same SPL. (see fig. 14.5 under sound-level measurements in phons)



http://www.jimprice.com/prosound/db.htm

Chapter 14 – Noise Pollution and Control

• **Sound Intensity (W/m^2) -** is proportional to the square of the root mean square (rms) value of a sound pressure or SPL

(**Note :**for every 10 dB increase in SPL, there is a 10 fold increase in sound intensity.)

•**Frequency Weighting Networks**- noise is broken down to bands of low-medium-high frequency. "A-weighted" network filters out low and high frequency where human ears is less efficient. [dBA is a.k.a A-weighted decibels]

[Refer to p.464 in text fig. 14.3]

Sound Level (SL)- Sound Level measurement over a period of time. i.e. L_{90}=75 dBA means 90% of the time sound level exceeeded 75 dBA.

Chapter 14 – Noise Pollution and Control

• **Sound Exposure Level (SEL) -** provides a basis for computing noise events of variable durations which matches a person's impression of noise. It is standardized to 1 sec. (**Note**: refer to figure 14.7, p. 465)

•**Equivalent Sound Level (Leq)-** is is the average or constant SPL over the period of interest. [i.e. Leq(8) is the average for an 8 hr. period.] [Refer to p.464 in text fig. 14.3]

•**Day - Night Sound Level (DNL)-** Leq(24) with a 10-dBA penalty for night time which is more annoying. see fig. 14.8

[**Note:** Noise can cause damage to our irritability, anxiety, stress and other emotional symptoms.]

Temporary Threshold Shift (TTS)- Temporary hearing loss (approx. 1 month)

Noise -induced permanent threshold shift (NIPTS) - loss of hearing with no chance of recovery

Chapter 14 – Noise Pollution and Control

• **less than 80 dBA -**no hearing loss
•**80 to 130 dBA** - TTS hearing loss is noticeable
•**50 % of people exposed to 95-dBA will experience NIPTS (permanent hearing loss)**
•**150 dBA or greater-** can physically rupture the human eardrum.

(**Note:** 1 hr. of 100 dBA can produce TTS whereas 8 hours of 95 dBA over 10 years may cause NIPTS)

$$SL_{\mathrm{B}} = S_A - 10\mathrm{X}\log\frac{\mathrm{D_B}}{\mathrm{D_A}}$$

Water Pollution

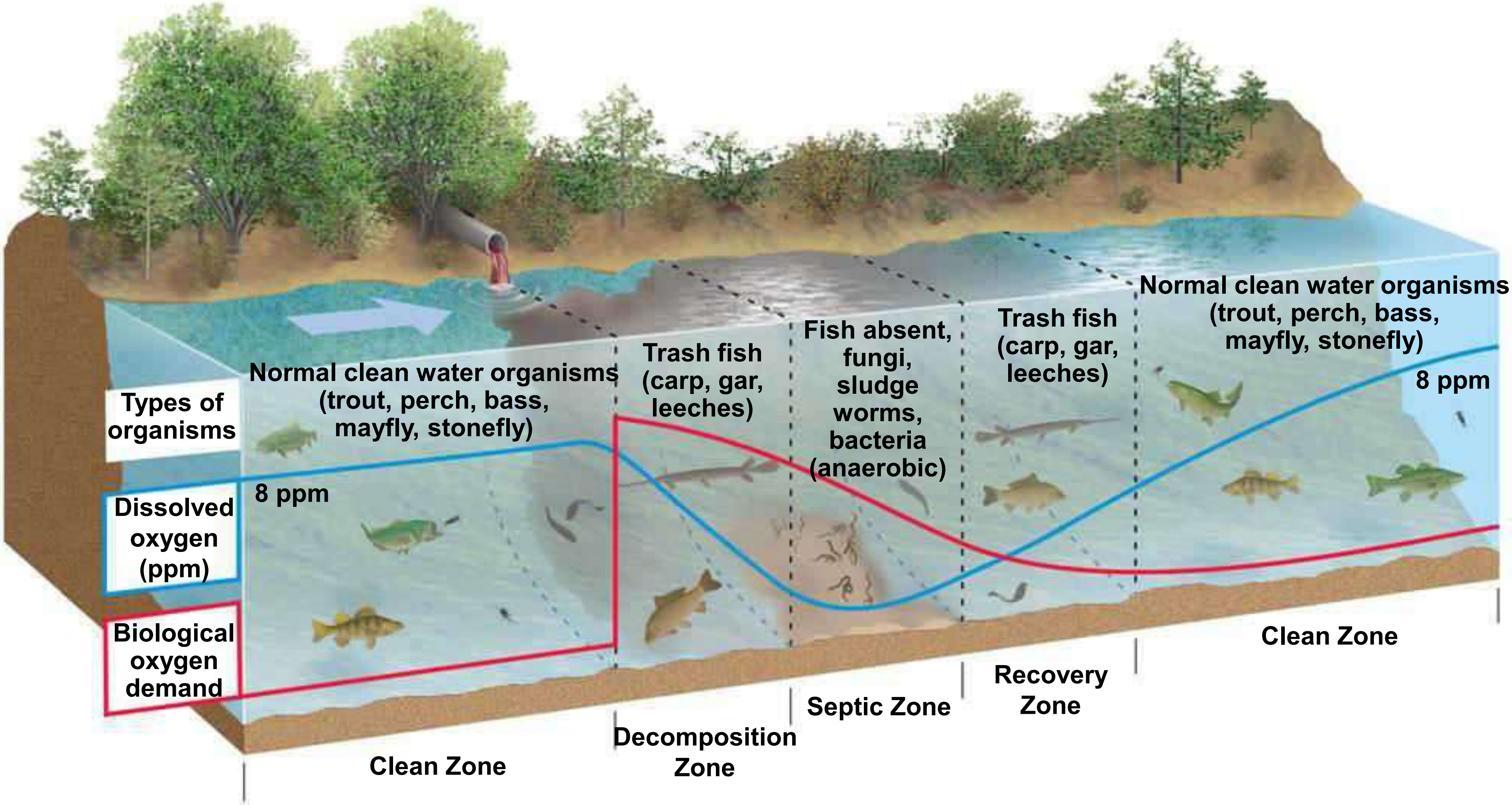
Water Pollution: Types, Effects, and Sources

- What is water pollution?
- Major types of pollutants, sources and effects
- Point and nonpoint sources
- Is the water safe to drink?

Major Categories of Water Pollutants

- Infectious Agents
  - Bacteria, Viruses, Protozoa, Parasitic Worms
  - Source: Human and animal waste
- Oxygen-Demanding Waste
  - Organic debris & waste + aerobic bacteria
  - Source: Sewage, feedlots, paper-mills, food processing
- Inorganic Chemicals
  - Acids, Metals, Salts
  - Sources: Surface runoff, Industrial effluent, household cleansers
- Radioactive Materials
  - Iodine, radon, uranium, cesium, thorium
  - Source: Coal & Nuclear Power plants, mining, weapons production, natural
- Plant Nutrients
  - Nitrates, Phosphates,
  - Source: Sewage, manure, agricultural and landscaping runoff
- Organic Chemicals
  - Oil, Gasoline, Plastics, Pesticides, Solvents, detergents
  - Sources: Industrial effluent, Household cleansers, runoff from farms and yards
- Eroded Sediment
  - Soil, Silt
- Heat/Thermal Pollution
  - Source: Power plants, Industrial

Pollution in Streams



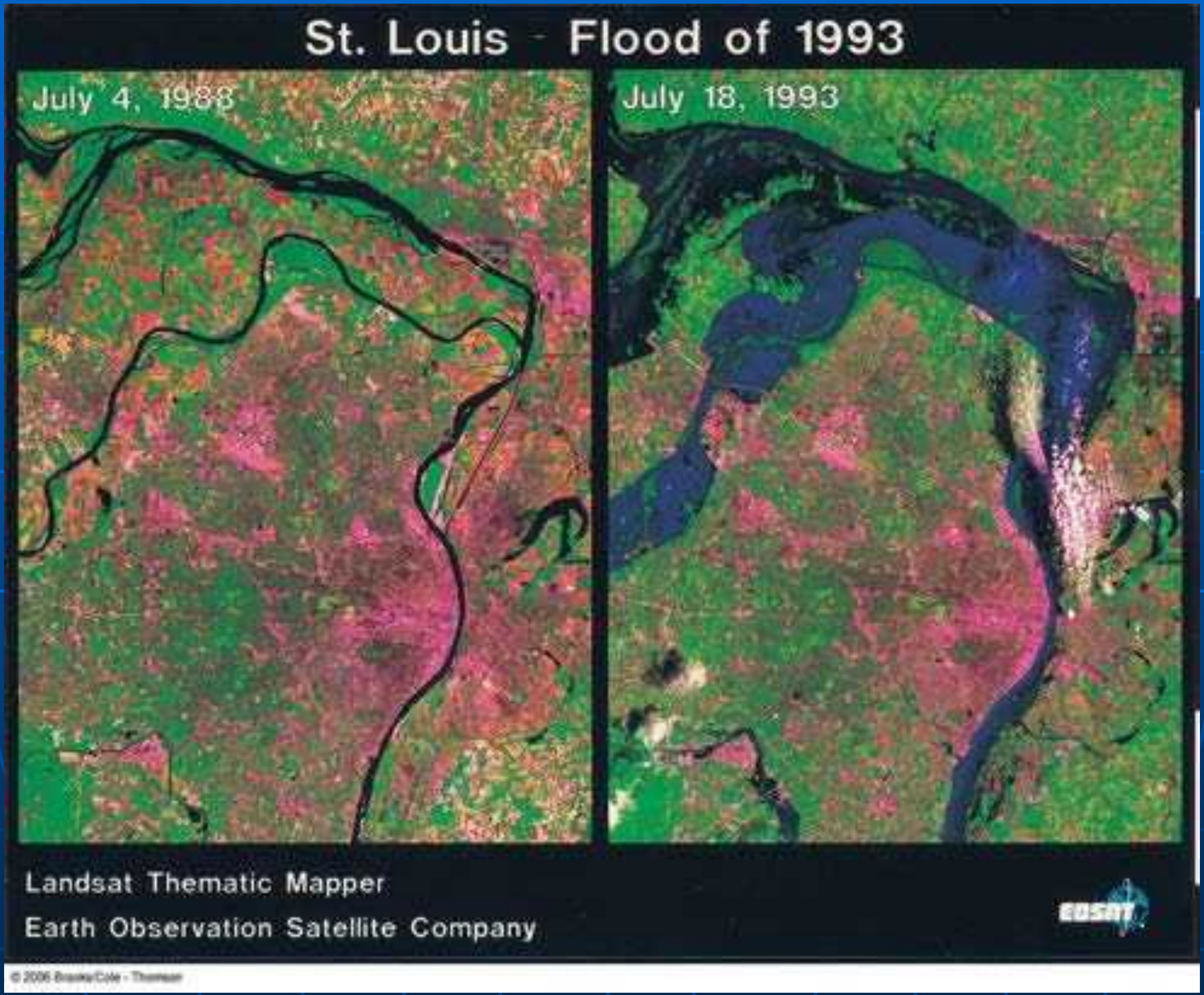
Benefits of Floodplains

- Highly productive wetlands
- Provide natural flood and erosion control
- Maintain high water quality
- Recharge groundwater
- Fertile soils
- Nearby rivers for use and recreation
- Flatlands for urbanization and farming

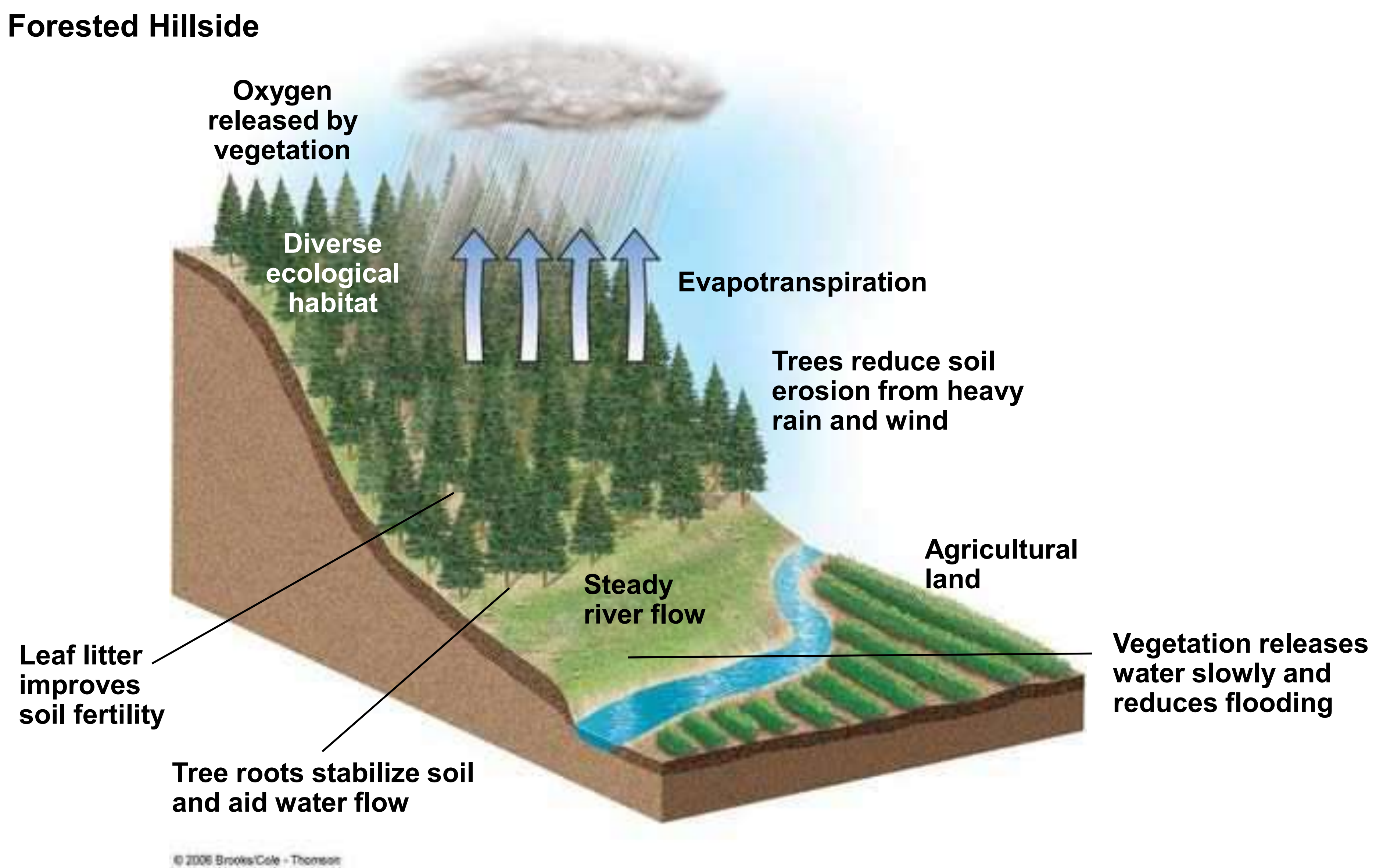
Dangers of Floodplains and Floods

- Deadly and destructive
- Human activities worsen floods
- Failing dams and water diversion
- Bangladesh

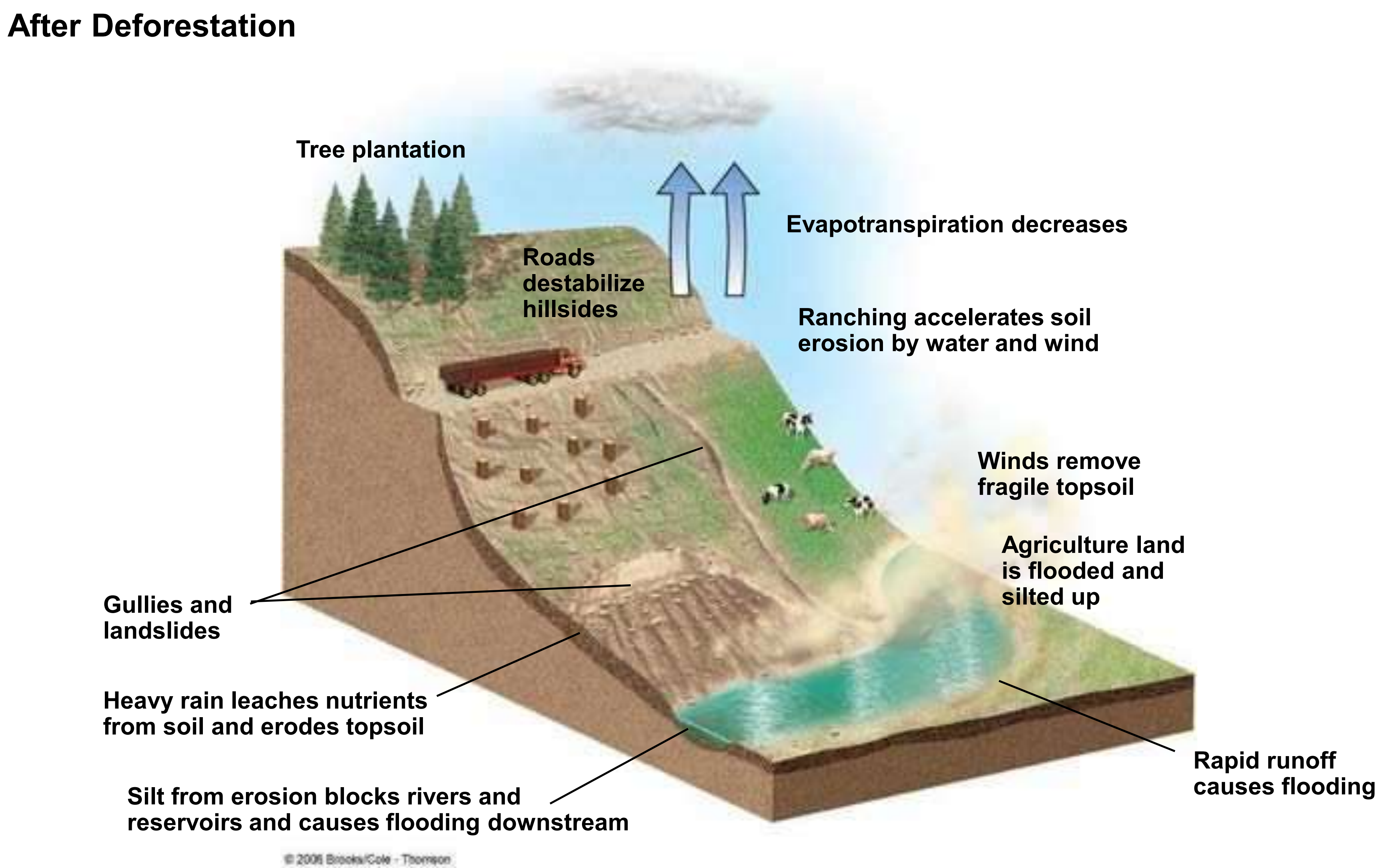
Before and During a Flood in St. Louis, Missouri



Flooding After Deforestation of a Hillside



Flooding After Deforestation of a Hillside



Reducing Flood Risks

- Channelization
- Levees (floodwalls)
- Dams
- Protect and restore wetlands
- Identify and manage flood-prone areas
- Precautionary approach

Lake Pollution

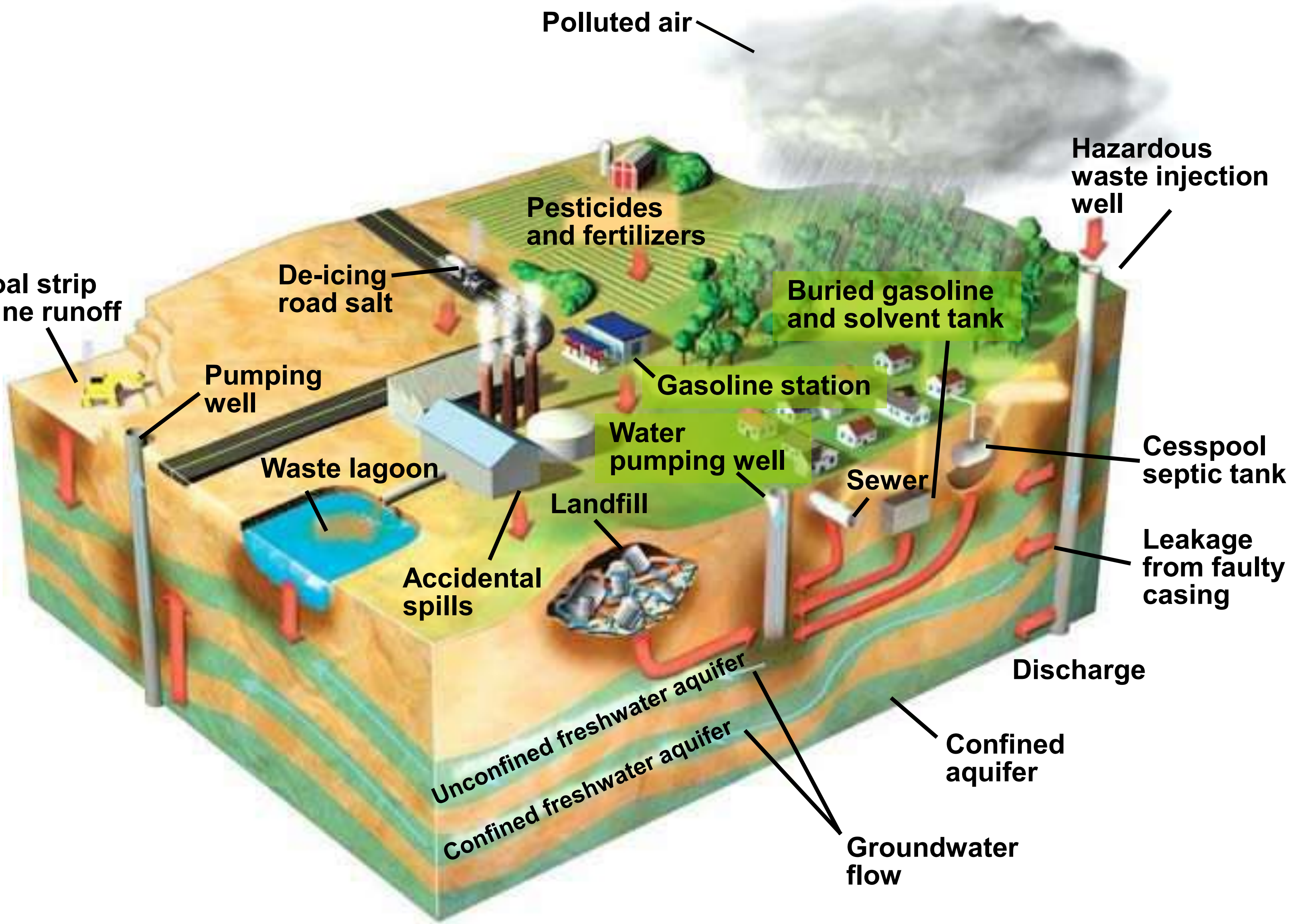
- Dilution less effective than with streams
- Stratification in lakes and relatively little flow hinder rapid dilution of pollutants
- Lakes more vulnerable to pollutants than streams
- How pollutants enter lakes
- Eutrophication: causes and effects
- Oligotrophic and eutrophic lakes
- Cultural eutrophication
- Preventing or removing eutrophication

Oligotrophic and Eutrophic Lakes

Groundwater Pollution: Causes and Persistence

- Sources of groundwater pollution
- Slow flowing: slow dilution and dispersion
- Consequences of lower dissolved oxygen
- Fewer bacteria to decompose wastes
- Cooler temperatures: slow down chemical reactions
- “Degradable” and nondegradable wastes in groundwater

Groundwater Pollution



Extent of Groundwater Pollution

- Not much is known about groundwater pollution
- Organic contaminants, including fuel leaks
- Arsenic
- Protecting groundwater: Prevention is best

Preventing and Cleaning Up Pollution in Groundwater

Solutions

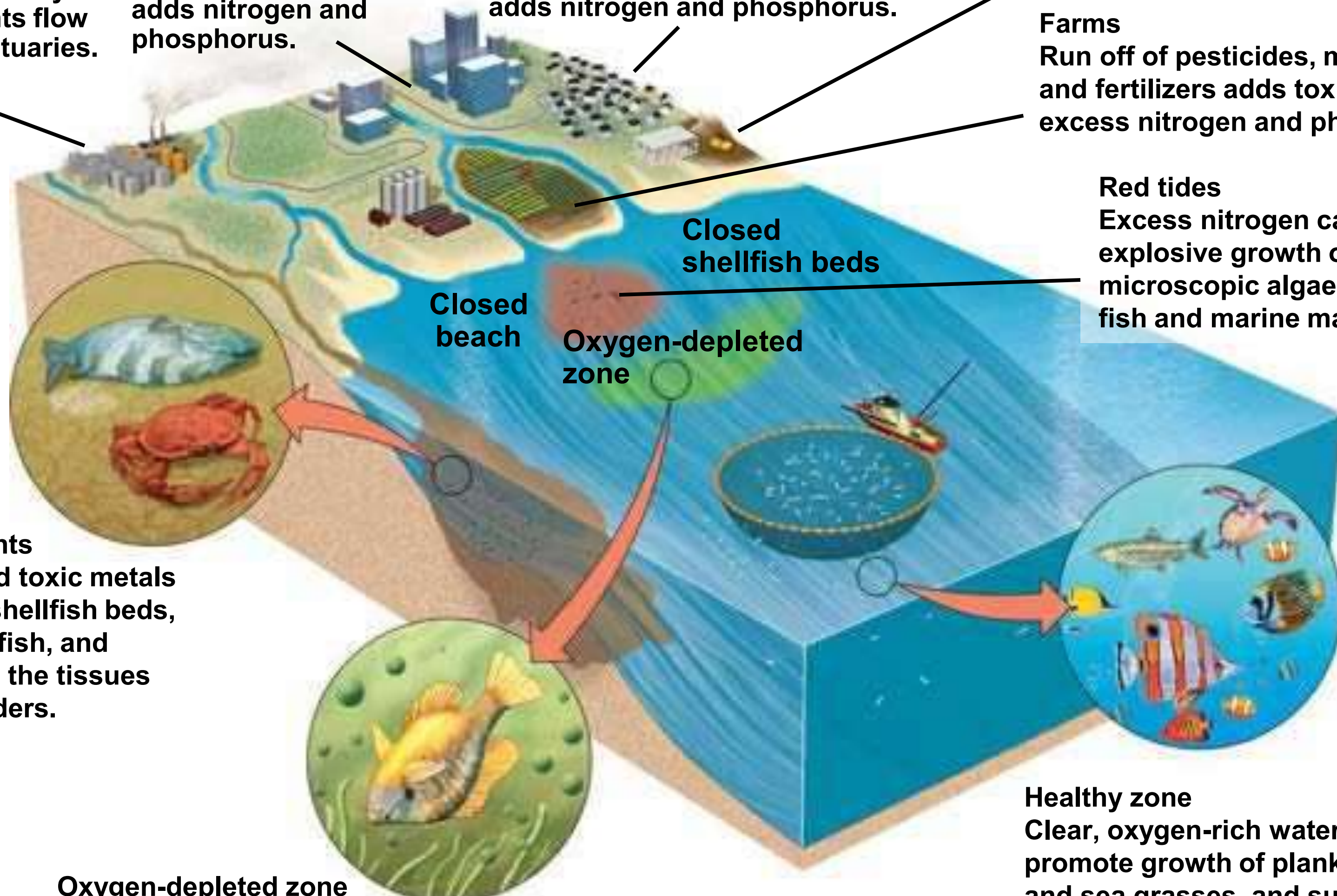
Groundwater Pollution

Prevention	**Cleanup**
Find substitutes for toxic chemicals	Pump to surface, clean, and return to aquifer (very expensive)
Keep toxic chemicals out of the environment	Inject microorganisms to clean up contamination (less expensive but still costly)
Install monitoring wells near landfills and underground tanks	Pump nanoparticles of inorganic compounds to remove pollutants (may be the cheapest, easiest, and most effective method but is still being developed)
Require leak detectors on underground tanks	
Ban hazardous waste disposal in landfills and injection wells	
Store harmful liquids in aboveground tanks with leak detection and collection systems	

Ocean Pollution

- How much pollution can oceans tolerate?
- Some pollutants degrade and dilute in oceans
- Ocean dumping controversies

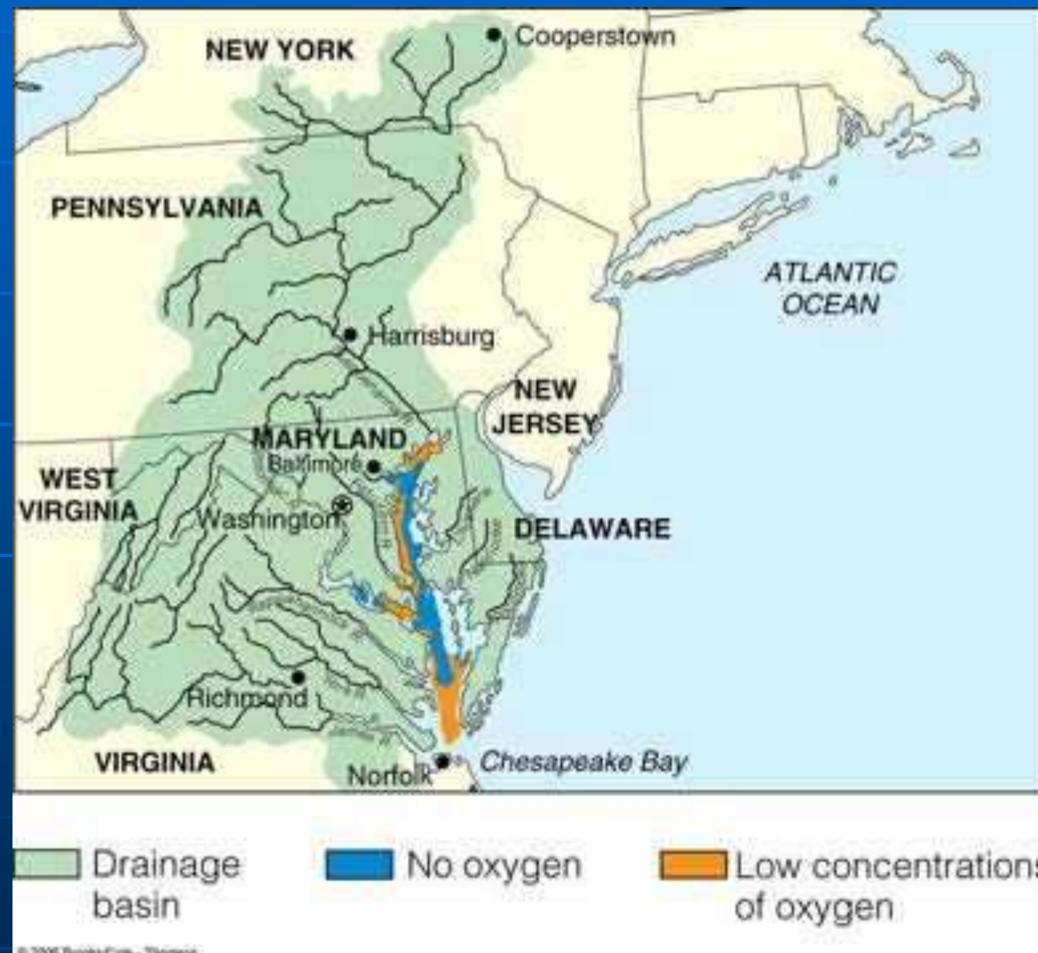
Coastal Water Pollution



Oxygen-depleted Water in the Gulf of Mexico

Chesapeake Bay

- Largest US estuary
- Pollution "sink"
- Oxygen depletion
- Chesapeake Bay Program



Effects of Oil on Ocean Life

- Crude and refined petroleum
- Tanker accidents and blowouts
- *Exxon Valdez*
- Volatile hydrocarbons kill larvae
- Tar-like globs coat birds and marine mammals
- Oil destroys insulation and buoyancy
- Heavy oil sinks and kills bottom organisms
- Coral reefs die
- Slow recovery
- Oil slicks ruin beaches
- Limited effectiveness of clean up methods

Preventing and Cleaning Up Pollution in Coastal Waters

Solutions

Coastal Water Pollution

Prevention	Cleanup
Reduce input of toxic pollutants	Improve oil-spill cleanup capabilities
Separate sewage and storm lines	Sprinkle nanoparticles over an oil or sewage spill to dissolve the oil or sewage without creating harmful byproducts (still under development)
Ban dumping of wastes and sewage by maritime and cruise ships in coastal waters	Require at least secondary treatment of coastal sewage
Ban ocean dumping of sludge and hazardous dredged material	Use wetlands, solar-aquatic, or other methods to treat sewage
Protect sensitive areas from development, oil drilling, and oil shipping	
Regulate coastal development	
Recycle used oil	
Require double hulls for oil tankers	

Preventing Nonpoint Source Pollution

- Mostly agricultural wastes
- Use vegetation to reduce soil erosion
- Reduce fertilizer use
- Use plant buffer zones around fields
- Integrated pest management: Only use pesticides when necessary
- Use plant buffers around animal feedlots
- Keep feedlots away from slopes, surface water and flood zones

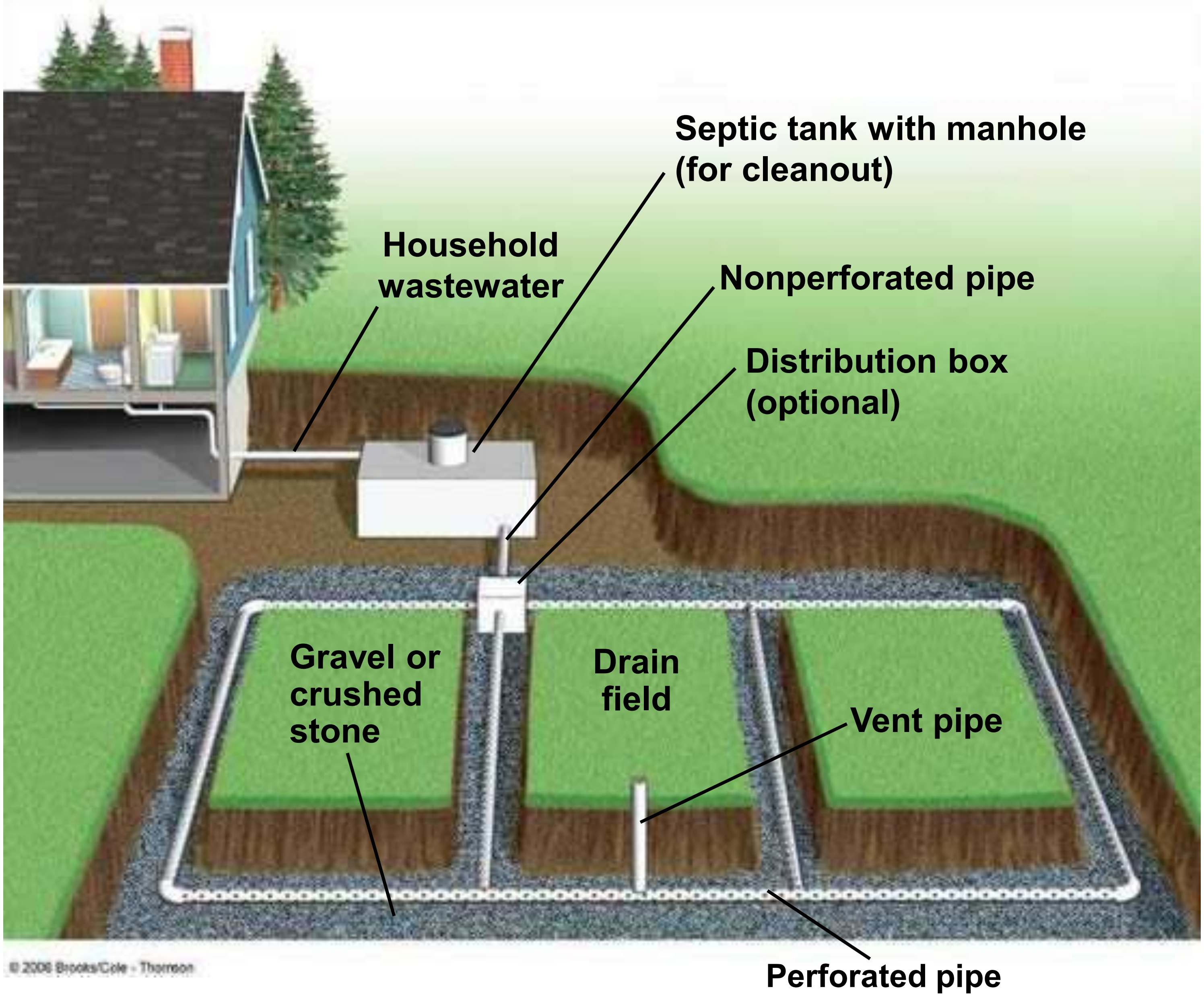
Laws for Reducing Point Source Pollution

- Clean Water Act
- Water Quality Act

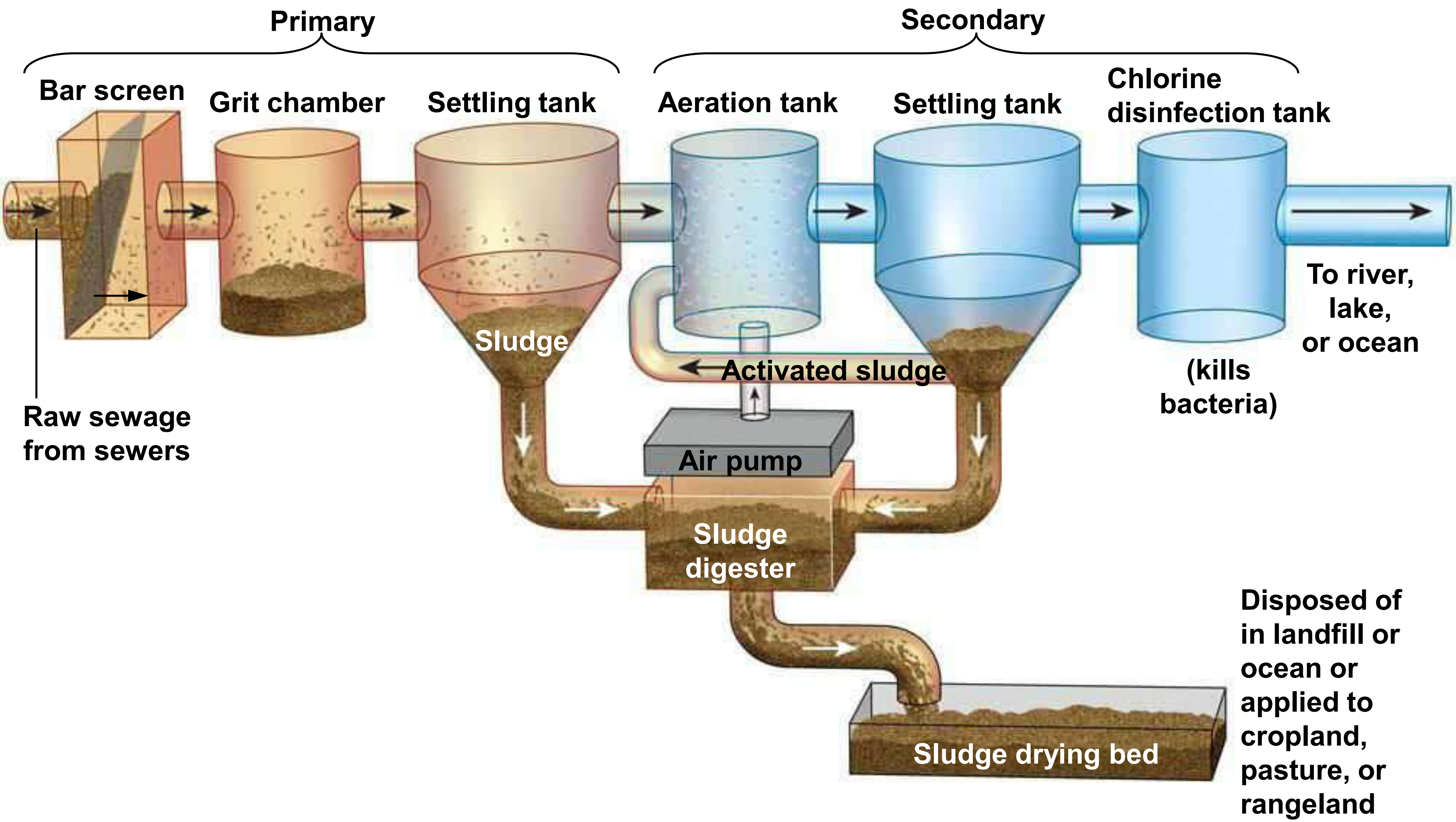
Sewage Treatment Systems

- Sewage treatment in rural and suburban areas
- Septic tanks
- Primary (physical) sewage treatment
- Secondary (biological) sewage treatment
- Urban sewage treatment (Clean Water Act)
- Sewage treatment facilities in many cities fail to meet federal standards
- Bleaching and disinfection
- Disinfectants: chlorine, ozone, and ultraviolet radiation

Typical Septic Tank System



Primary and Secondary Sewage Treatment



Improving Sewage Treatment

- Systems that exclude hazardous wastes
- Non-hazardous substitutes
- Composting toilet systems
- Working with nature to treat sewage
- Using wetlands to treat sewage

Ecological Wastewater Treatment

Burlington, VT
University of Vermont

Should the Clean Water Act be Strengthened?

- Yes: environmentalists
- No: farmers, libertarians, manufacturers, and developers

State and local officials want more discretion

Drinking Water Quality

- Purification of urban drinking water
- Purification of drinking water in developing countries
- Bottled water

Solutions

Water Pollution

- Prevent groundwater contamination
- Greatly reduce nonpoint runoff
- Reuse treated wastewater for irrigation
- Find substitutes for toxic pollutants
- Work with nature to treat sewage
- Practice four R's of resource use (refuse, reduce, recycle, reuse)
- Reduce resource waste
- Reduce air pollution
- Reduce poverty
- Reduce birth rates

What Can You Do?

Water Pollution

- Fertilize your garden and yard plants with manure or compost instead of commercial inorganic fertilizer.
- Minimize your use of pesticides.
- Never apply fertilizer or pesticides near a body of water.
- Grow or buy organic foods.
- Compost your food wastes.
- Do not use water fresheners in toilets.
- Do not flush unwanted medicines down the toilet.
- Do not pour pesticides, paints, solvents, oil, antifreeze, or other products containing harmful chemicals down the drain or onto the ground.

Water Treatment Processes

Disinfection and removal of solids

Contents

1.Aim of treatment

1. Aim of the treatment process

- Multiple options of treatment
- Safe water supply:

  "All people have safe and equitable access to a sufficient quantity of water for drinking, cooking and personal and domestic hygiene."

  "Water is palatable, and of sufficient quality to be drunk and used for personal and domestic hygiene without causing significant risk to health"

  (The Sphere Project, Chap.2, Norms 1 y 2)

1. Aim of the treatment process

- ❑ Pathogen free
- ❑ Chemically safe
- ❑ Without dirt solid matter
- ❑ Aesthetically acceptable

WHO Guidelines

National Regulation

1. Aim of the treatment process

- The treatment process starts in the water extraction
    - Source selection (surface water/groundwater)
    - Means of water extraction (strainer)
- The treatment process ends in the distribution
    - Storage and distribution
    - Jerry cans for the beneficiaries
    - Re-contamination risks

2. Removal of solids in suspension

2. Removal of solids in suspension

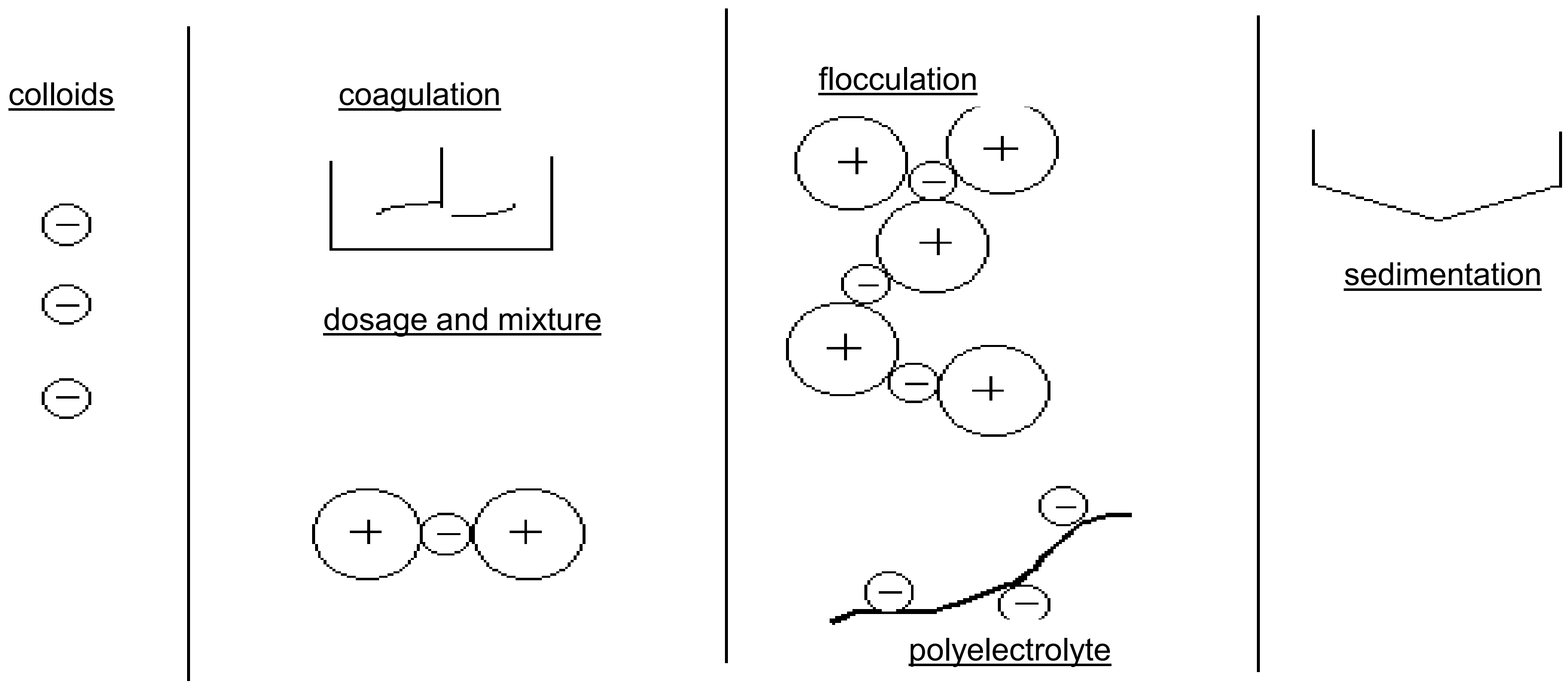
- Why?
  - aspect
  - efficiency of disinfection
- Control parameter: Gravity analysis
  Turbidity (NTU)
- Aim: < 5 NTU
- Methods
  - Sedimentation
  - Flocculation
  - Filtration

2. Removal of solids in suspension. Sedimentation

- Advantages: Simple, no consumption
- Disadvantages: Need of facilities, slow, limited

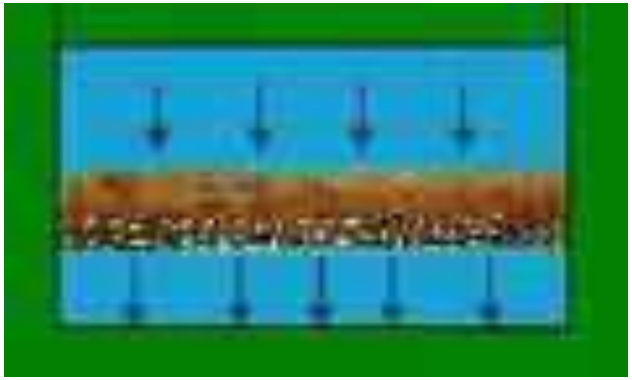
2. Removal of solids in suspension. Flocculation

- Advantages: Removes colloids, time, equipment
- Disadvantages: Chemicals, factor control (temp. time, dosage)

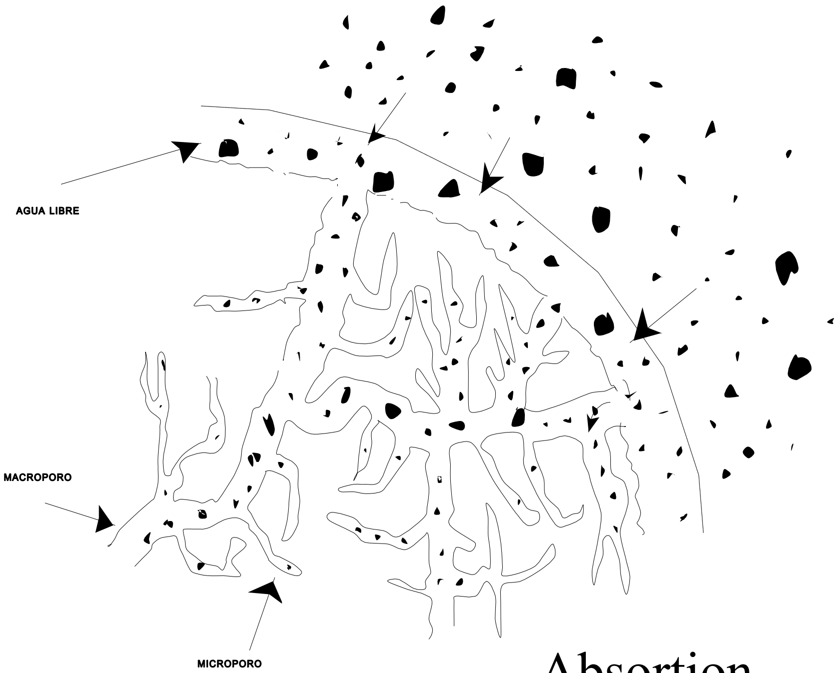


2. Removal of solids in suspension. Filtration

- Advantages: No chemicals, modules, possible sterilization
- Disadvantages: Material (means of filtration) and facilities



Filtration + Back washing



Absortion
Active carbon

3. Disinfection

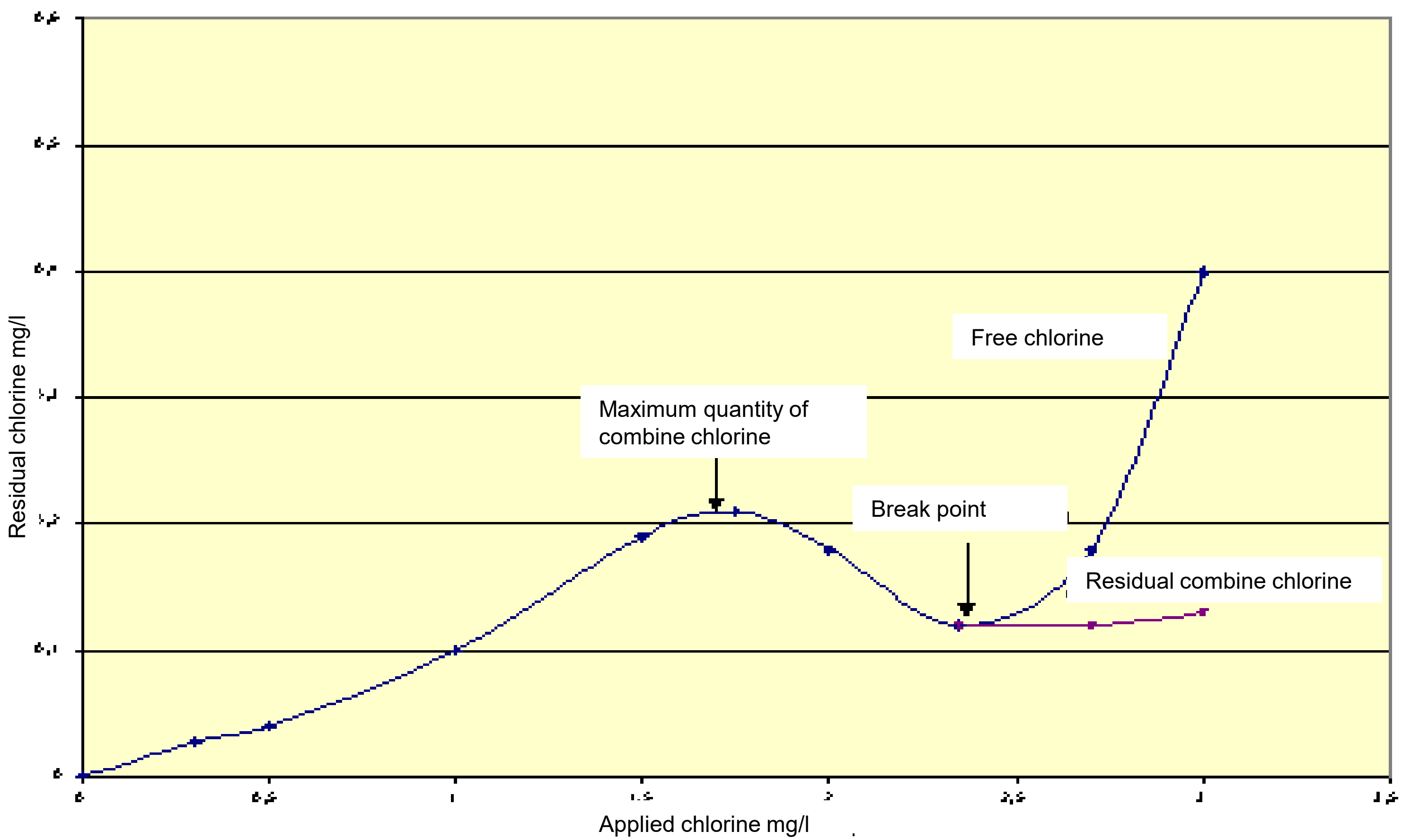
3. Disinfection: Aims

- To destroy the germs present in the raw water
- To destroy the germs introduced in the treatment and distribution systems (pipeline and storage)

3. Disinfection: Procedures

- Properties of disinfection agents
- Physical agents: heat, UV radiation
- Chemical agents: chlorine, ozone, iodine, salts of ammonium…
  - Chlorination
  - Calcium hypochlorite HTH 70 % of active chlorine

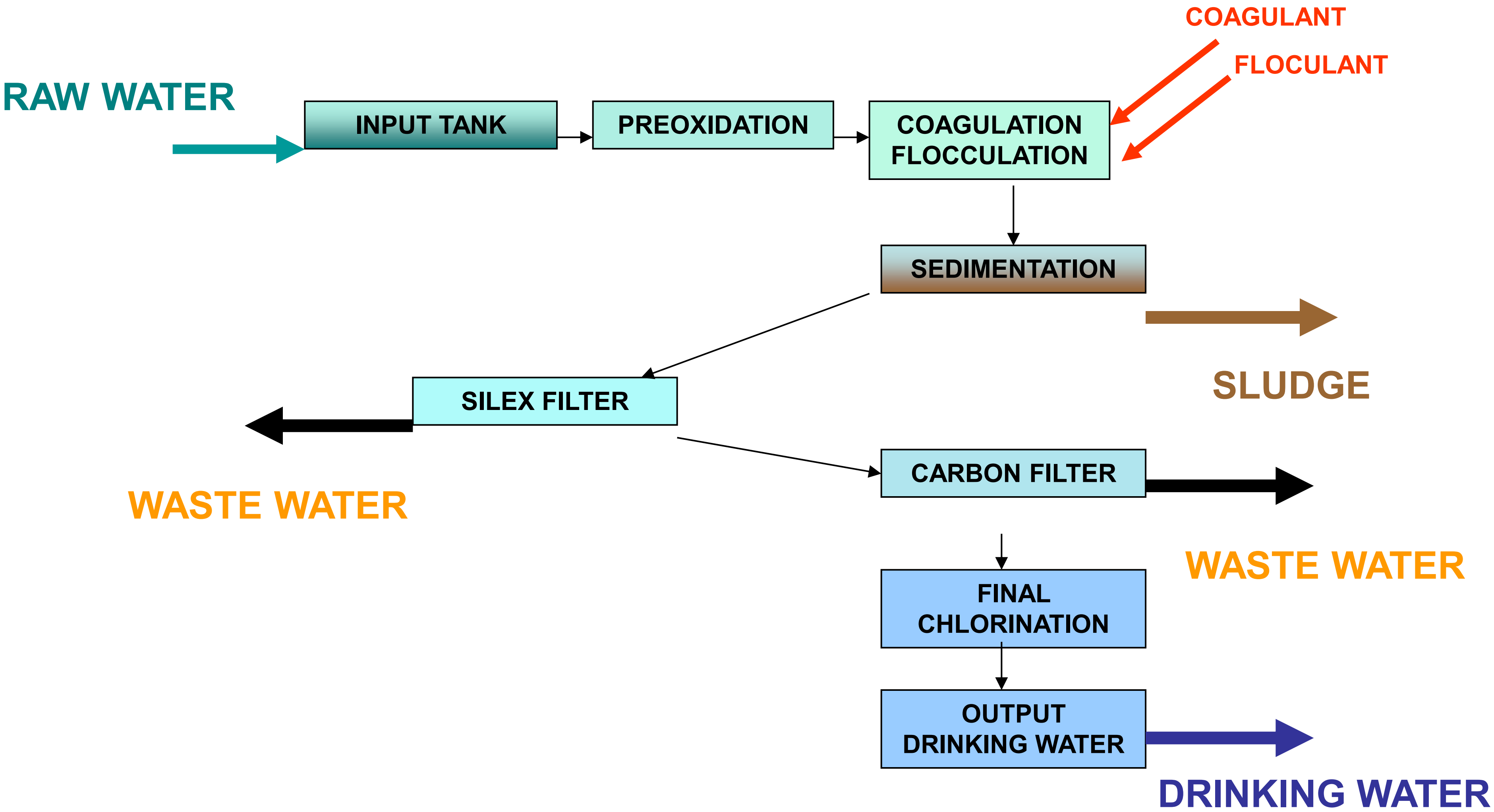
3. Disinfection: Chlorination dosage



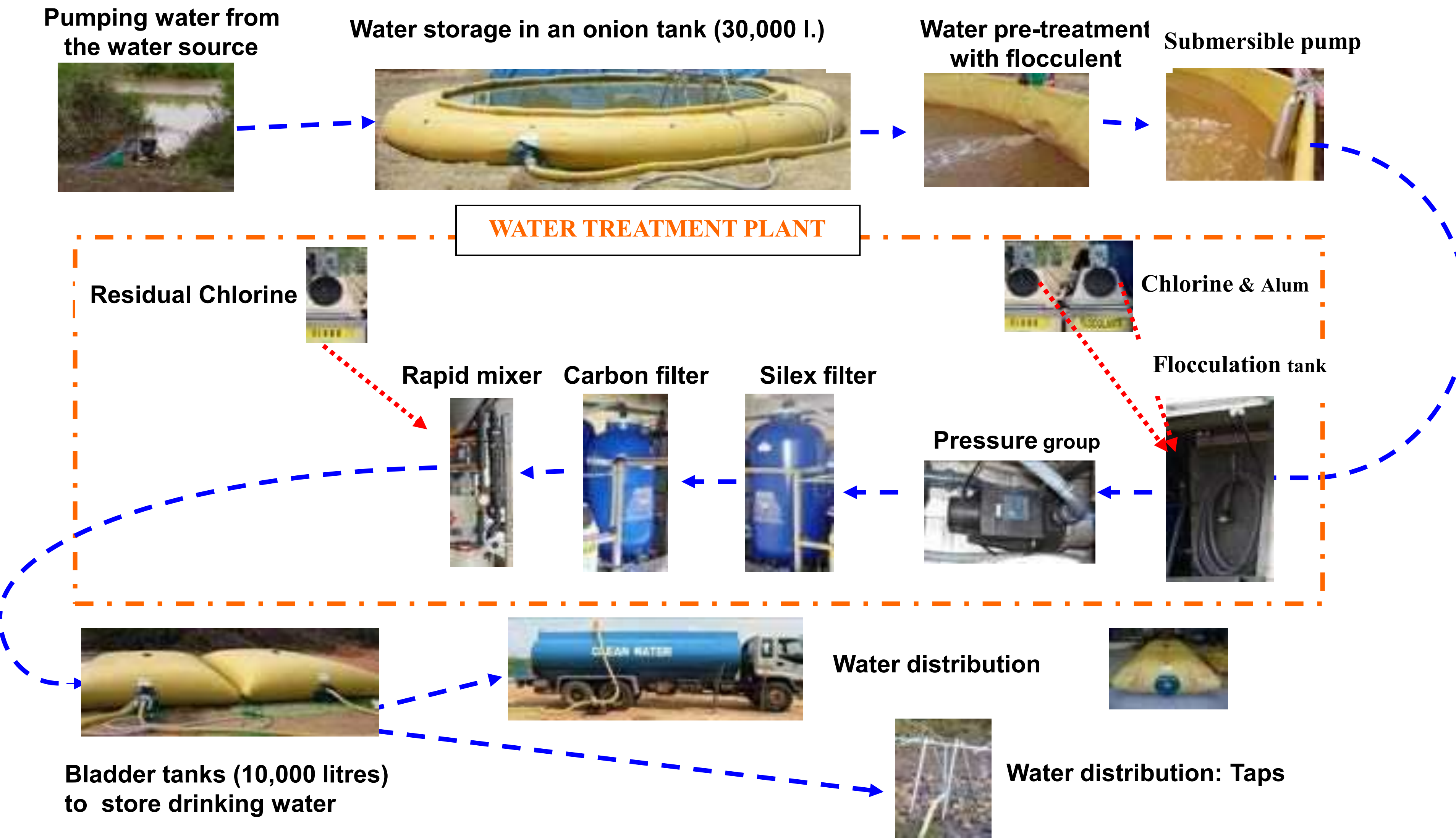
3. Disinfection: Chlorination

- Dosage: Chlorine request test
- Contact time
- pH and temperature
- Final ranges: 0.4 - 0,8 mg/l
- Shock chlorine

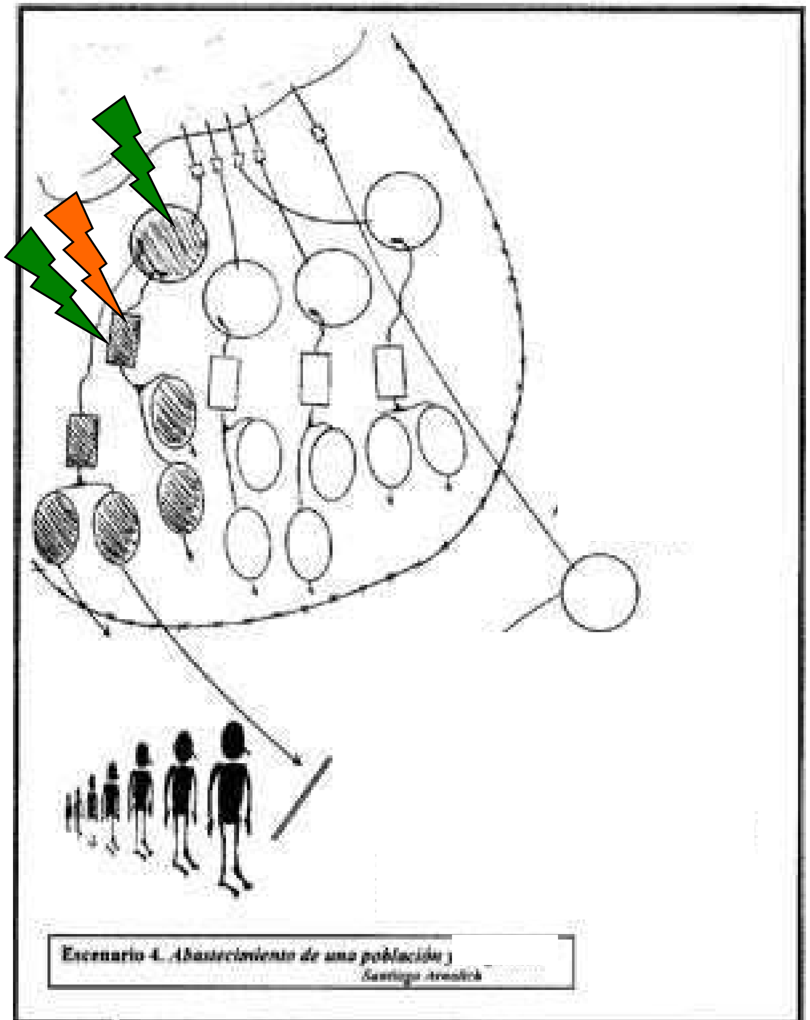
DIAGRAMME


COAGULANT
FLOCULANT
RAW WATER
INPUT TANK
PREOXIDATION
COAGULATION FLOCCULATION
SEDIMENTATION
SLUDGE
SILEX FILTER
WASTE WATER
CARBON FILTER
WASTE WATER
FINAL CHLORINATION
OUTPUT DRINKING WATER
DRINKING WATER

4. Water treatment in emergencies


Pumping water from the water source
Water storage in an onion tank (30,000 l.)
Water pre-treatment with flocculent
Submersible pump
WATER TREATMENT PLANT
Residual Chlorine
Chlorine & Alum
Flocculation tank
Rapid mixer
Carbon filter
Silex filter
Pressure group
CLEAN WATER
Water distribution
Water distribution: Taps
Bladder tanks (10,000 litres) to store drinking water

4. Water treatment in emergencies



- ***Specialized water production***

FLOCCULATION

– pre-treatment in the tank

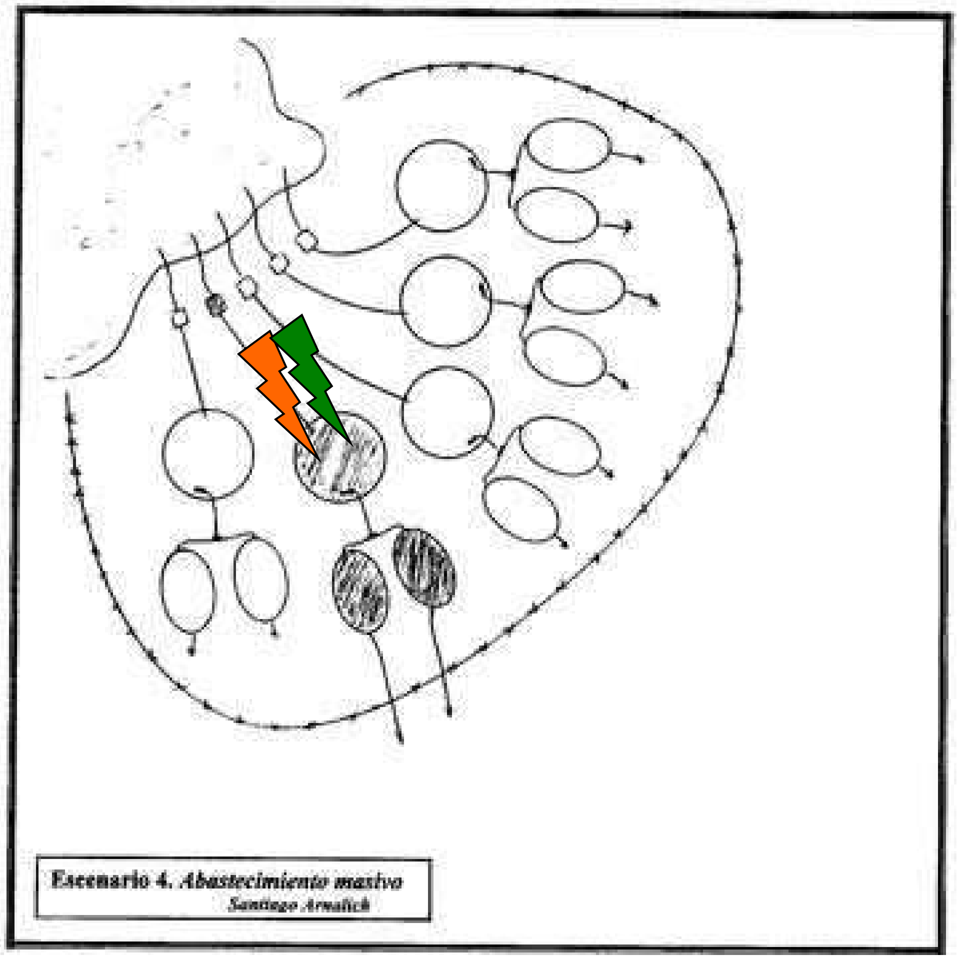
– treatment in the sedimentation tank in the WTP

CHLORINATION

– in the WTP (shock & residual)

4. Water treatment in emergencies

4. Water treatment in emergencies



- ***Mass water production***

  FLOCCULATION
  – in the tank as chlorination pre-tretament

  CHLORINATION
  – in the tank

4. Water treatment in emergencies

Thank you……….

SUSTAINABILITY

Anand Pendharkar

Ecologist & Director

SPROUTS

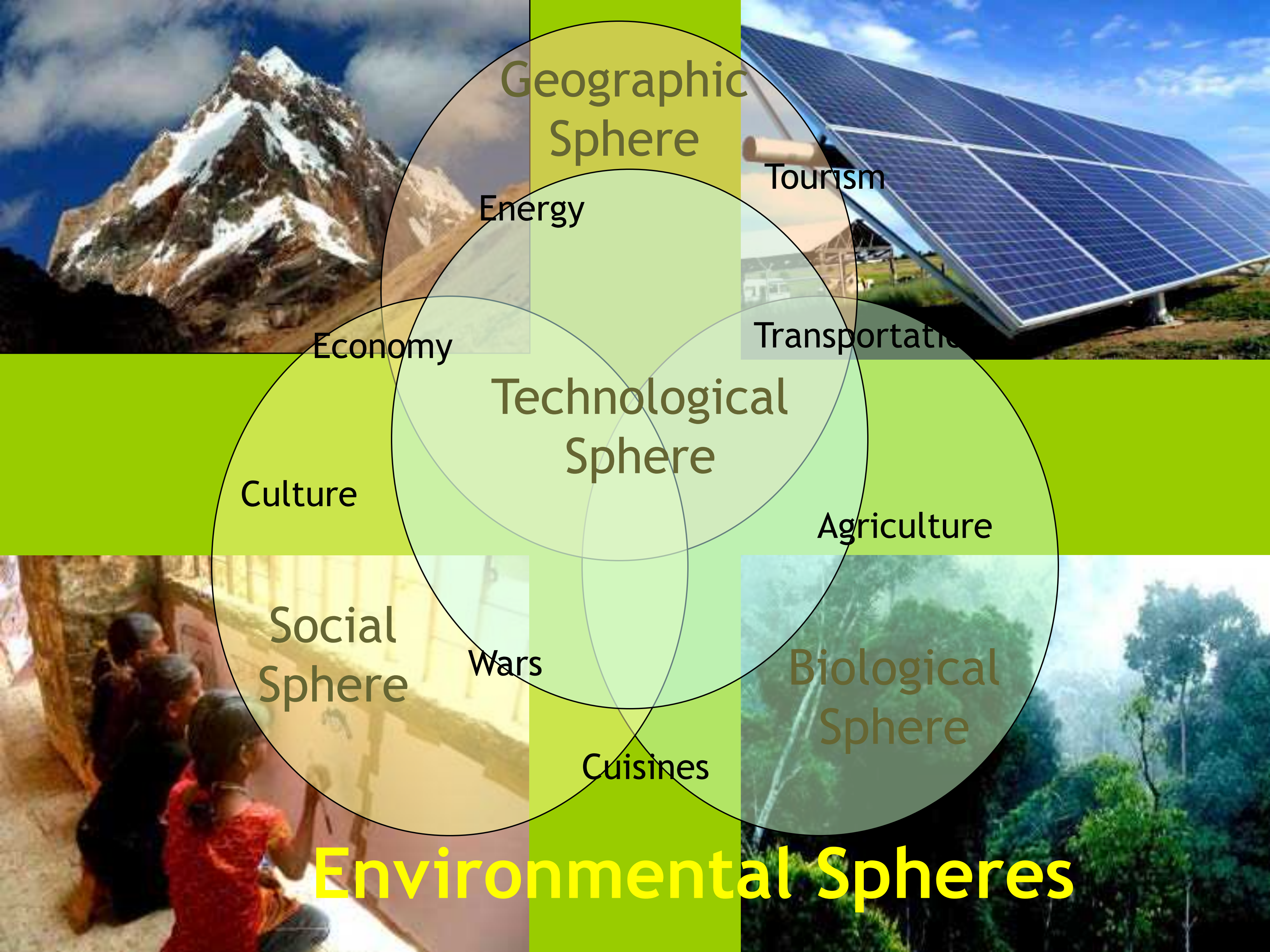
Society for Promotion of Research, Outdoors, Urbanity, Training & Social Welfare

What do you mean by **Sustainability**?

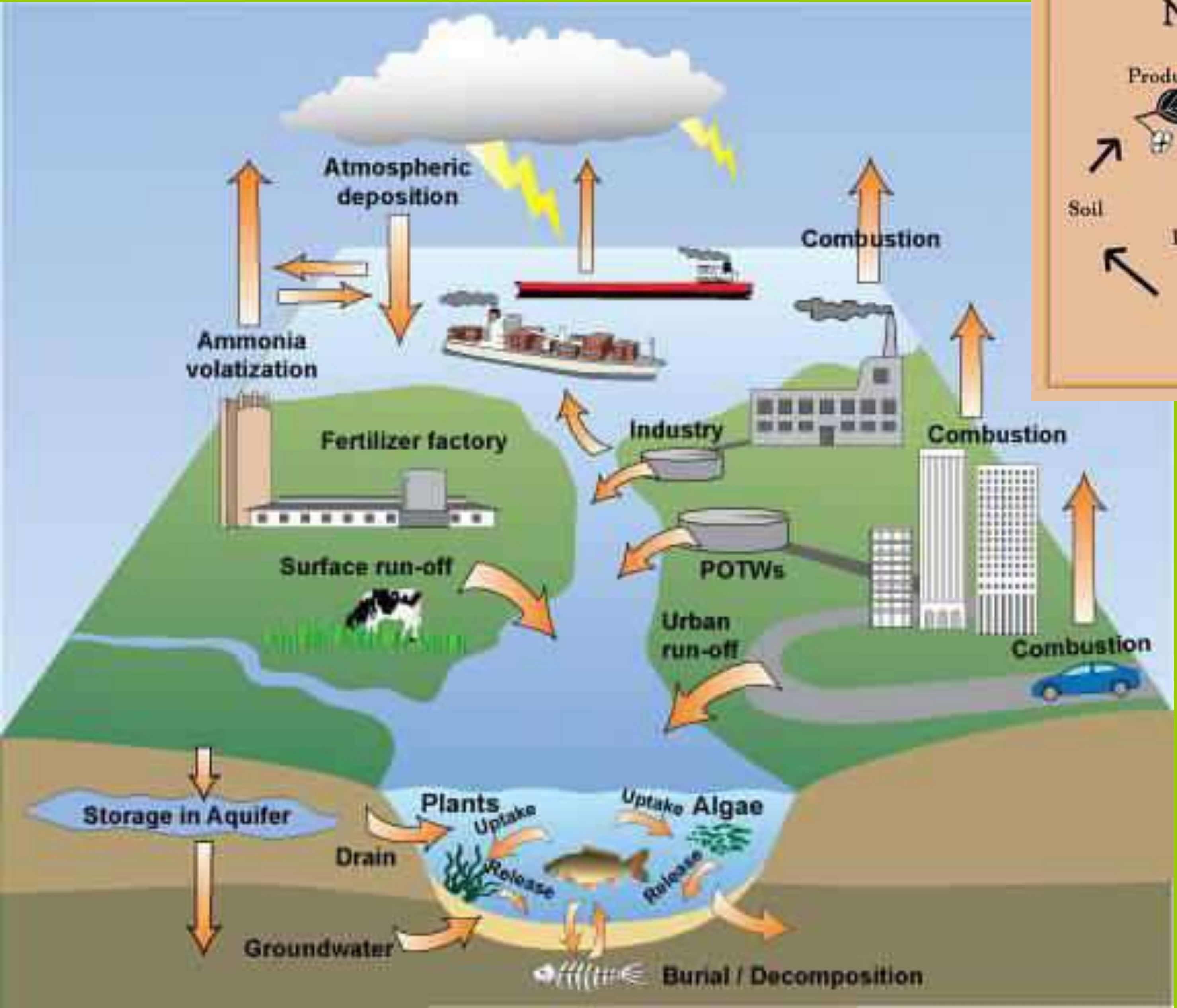
Sustainability is the capacity to hold & maintain for long-term

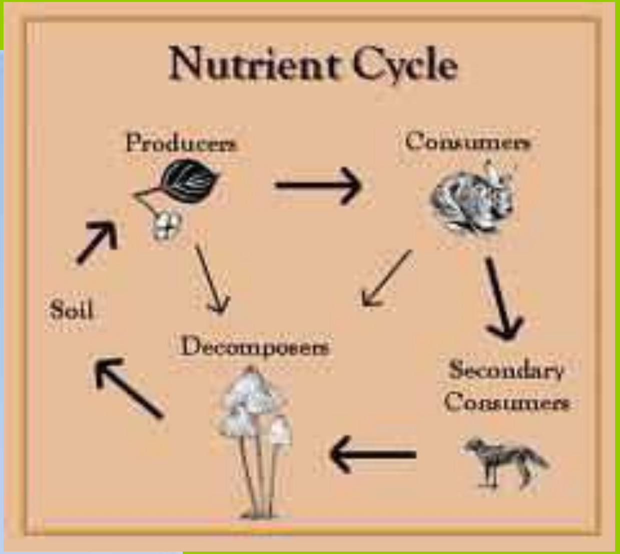
Long-term maintenance of ecosystem components & functions for future generations.

For humans, sustainability is the potential for long-term maintenance of well being, which has environmental, economic and social dimensions.


Geographic Sphere
Tourism
Energy
Economy
Transportatio
Technological Sphere
Culture
Agriculture
Social Sphere
Wars
Biological Sphere
Cuisines
Environmental Spheres

Cycling of Nutrients in Nature & Human Systems






CO_2




Sustainable Development

What needs to be sustained

Nature: earth, biodiversity, ecosystems
Life support: ecosystem services, resources, environment
Community: cultures, groups, places

What needs to be developed

People: child survival, life expectancy, education, equity, equal opportunity
Economy: wealth, productive sectors, consumption
Society: institutions, social capital, states, regions

What are the key themes to Sustainable Development today?!

- Meeting human needs
- Equality
- Overcoming Envt.al limits
- Future impacts
- Democracy
- Local to Global

What does sustainability look like?

Sustainability is not a stand still…

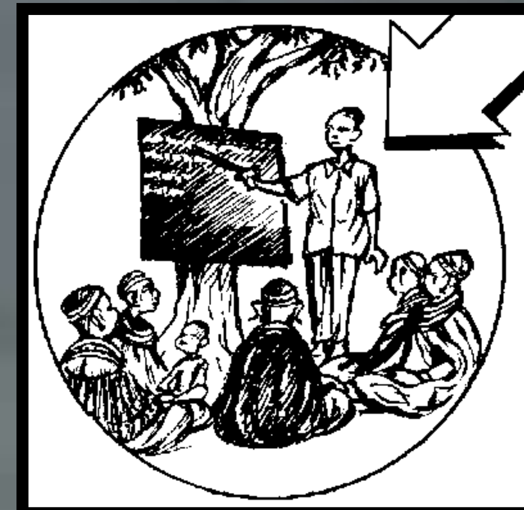
- New Approaches, Constant Change!
- Learning's to change People's Attitudes & Behaviours
- Focus on helping people to find new ways of adapting constantly (to change)
- Thinking about how people behave, why they behave in the ways they do, and how to change that – to tackle unsustainable local production and consumption e.g. Plastic bags, DDT, Fossil-fuelled Pvt Cars, Water Parks!!!

ECO TOURISM = SUSTAINABILITY

- Travelling to natural destinations which builds Envtal awareness
- Provides direct financial benefits for conservation
- Conservation of biological and cultural diversity through ecosystem protection
- Promotion of sustainable use of biodiversity, by providing jobs to local people
- Sharing of socio-economic benefits with local communities by having their permission and participation in the management of ecotourism enterprises

WHAT ONE SHOULD DO . . .

- Develop sensitivity
- Be aware of environmental impacts
- Remove 'Not in my backyard Attitude'
- You change - then look at others
- Try to compromise at least
- Make an attempt
- Refuse, Reduce, Reuse, Recycle



HELP!

ORGANIZE A CLEAN-UP IN YOUR AREA.

Clean-up & Educate

Involve

Restore

Solar torch

Solar lamp

Solar panels on roof top

City Farming

Fish Breeding

Wind Mills

SUSTAINABLE METHODS


SPROUTS
Only one PLANET

SPROUTS

Society for Promotion of Research, Outdoors, Urbanity, Training & Social Welfare

ONLY WE HAVE THE SOLUTION

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Environmental Impact Assessment

Environmental Impact Assessment

- Concept of Environmental Impact
- Role /Need of EIA
- Indian policies requiring EIA
- Screening/ scoping in the EIA process
- Essential elements of EIA
- Detailed activities in an EIA
- Environmental Evaluation System
- Environmental Impact Statement
- Environmental Management Plan

Concept of Environmental Impact

- effects of proposed projects, plans, programs, or legislative actions
- relative to the physical chemical, biological, cultural and socioeconomic components of total environment
- quantitative estimate
- before, during, and after the proposed action
- systematic identification and evaluation of the potential impacts

Environmental Impact

- any alteration of environmental conditions or creation of a new set of environmental conditions
- effects on the resource base

Primary Impacts

- project "inputs" generally cause primary impacts
- attributed directly to the proposed action
- primary impacts are generally easier to analyze and measure

Secondary Impacts

- Secondary impacts are indirect or induced changes
- indirect or induced changes,
- typically include the associated investments

  and changed patterns of social and economic activities likely to be stimulated or induced by proposed action.
- also included would be any planned

  increase in growth rate or level
- secondary impacts are usually more

  difficult to measure

In the biophysical environment, the secondary impacts can be especially important.

Impacts resulting from proposed actions can be placed in one or more of the following categories :

1. Beneficial or detrimental
2. Naturally reversible or irreversible
3. Repairable via management practices or irreparable
4. Short term or long term
5. Temporary or continuous

6. Occurring during the construction phase or the operational phase
7. Local, regional, national or global
8. Accidental or planned (recognized beforehand)
9. Direct (primary)

Effects or Impacts

- may include growth inducing impacts and other impacts related to induced changes in the pattern of land-use, population density or growth rate and related effects on air, water and other natural systems, including ecosystems
- effects may be ecological, aesthetic, historic, cultural, economic, social or health related, whether direct, indirect or cumulative. may have both beneficial and detrimental effects

1) Direct Effects/Impacts :- caused by the action and occur at the same time and place

2) Indirect Effects/Impacts :- caused by the action but later in time or further removed in distance, yet reasonably foreseeable

3) Cumulative Impacts :- incremental impact of the action when added to the other past, present and reasonably foreseeable future actions,
   - regardless of what agency
   - can result from individually minor, but collectively significant actions

Environmental Inventory

: complete "description of the environmental setting without the project"compiled from a checklist of descriptors for the physical-chemical, biological, cultural, and socioeconomic environments

- "Physical Chemical Environment" - includes such major areas as soils, geology, topography, surface water and ground water resources, water quality, air quality and climatology.
- "Biological Environment" – include flora and fauna of the area, including species of trees, grasses, insects, fishes, reptiles, birds and mammal with special emphasis on the endangered.

- "Cultural Environment" - include historic and archaeological sites and aesthetic resources such as visual quality
- "Socioeconomic Environment"- includes population trends and distribution, economic indication of human welfare, educational system, transportation networks and other infrastructure concerns such as water supply, wastewater disposal and solid waste management, public services. etc.
- Earlier only technical & economic factors dominated the decision making process.
- Now also environmental, social &other factors.

An Idealist Approach to EIA.

- Apply to all projects that are expected to have significant environmental impacts and address all impacts that are expected to be significant
- Compare alternatives to a proposed project

  (including possibility of non development of site)
- Result in a clear EIS which conveys the importance of the likely impacts and their specific characteristics to non-experts as well as experts

An Idealist Approach to EIA (cont….)

- Include broad public participation and stringent administration review procedures
- Be timed so as to provide information for decision making
- Be enforceable
- Include monitoring and feedback procedures

The Need for EIA

- Due to benefits
- Government policies requiring EIA

Benefits of EIA:

- helps to ensure that development options under consideration are sustainable
- helps to foresee potential problems likely from a proposed development and address them in the project planning and design stage
- can enable the incorporation of improvements and mitigation measures in a project's development
- can prevent future liabilities or costly alternatives in project design.
- can generate alternate routes for development process technologies and project sites

Benefits of EIA (Cont….)

- establishes qualitative values for parameters indicating the quality of environmental activity, thus allowing measures that ensure environmental compatibility

  presents a clear and concise picture of all costs and benefits associated with alternative causes of action

- provide a mechanism for merging the concerns for environment and economics in the process of decision making

- can provide guidelines for developmental activities in the context of regional carrying capacity

Indian Policies Requiring EIA

Environment (Protection) Act 1986, provides a legislative framework for :

* Protection and improvement of the environment
* Implementation of India's commitments relating to the protection and improvement of the environment, and prevention of hazards to human beings, other living creatures and property; ratified under the United Nations Conference on Human Environment (June 1972). To achieve the above objectives, a notification on EIA was issued on Jan.27,1994 and amended in May, 1994 and April, 1997. The latest amendment has introduced public hearing into the EIA process.

Situations where EIA is required in India

* Any new project as in Schedule I
- Pollution loads are increased through the expansion or modernization.

Impact Prediction

: is a way of 'mapping' the environmental consequences of the significant aspects of the projects and its alternatives

- element of uncertainty is always present when making predictions
- impacts should be determined for Air, Water, Land, Biota and the Socio-economic environment.

Impact Prediction (Cont…)

Air - total emissions

- changes in ambient levels and ground level concerns
- effects on climate, soils, material, vegetation and human health

Water - availability of supply

- changes in quality
- sediment transport
- effects to groundwater
- surface and groundwater quality

Land - changes in land use

- changes in land quality

Impact Prediction (Cont….)

Biota - changes in existing numbers of terrestrial plants and animals
- effects on existing numbers of terrestrial plants and animals
- effects of contaminants
- effects on rare and endangered species, endemic species, migration path

Socio - impacts on the community

Economic - effects on economic status
- effects on health

Assessment of Alternatives and delineation of mitigation measures

- various alternatives are identified and compared from an environmental perspective
- a mitigation plan is drawn which is supplemented with an EMP to guide the proponent towards ongoing environmental improvement.

Post Project Monitoring and Auditing

- carried out during the construction and operation of a project.
- to observe that during that project operation the prediction and agreements of EIS are complied with.
- where impacts exceed those predicted, action should be taken.

Detailed activities in an EIA

Air Environment

- Determination of impact zone and monitoring network
- Determination of existing status of ambient air quality within the impacted region (7-10) km radius of the proposed plant
- Collection of surface meteorological data viz, wind speed, direction, humidity, temperature and lapse rate
- Estimation of air emissions
- Identification, quantification and evaluation of other potential emissions within the impact zone and estimation of cumulative emissions

Air Environment (Cont…)

- Prediction of changes in ambient air quality through appropriate model
- Evaluation of the adequacy of the proposed pollution control devices to meet gaseous emission and ambient air quality standards
- Delineation of suggested mitigation measures at source, pathways and receptor

Noise Environment

* Assessment of the present status of noise levels within the impact zone and prediction of future noise levels resulting from the project
* Prediction and evaluation of impacts due to any anticipated rise in noise levels on the surrounding environment
* Recommendations on mitigation measures for noise pollution

Water Environment

* Study of existing ground and surface water resources with respect to its quantity and quality within the impact zone of the proposed project

* Prediction of impacts on water resources due to the proposed water use by the project

* Assessment of the WW quantity and characterization including toxic or organic, and proposed effluent quantities

Water Environment

* Evaluation of the proposed pollution prevention and WW treatment system and suggestions on modification, if required

* Prediction of impacts on the quality of the receiving water body using appropriate mathematical/simulation models

* Assessment of the feasibility of water recycling and reuse and delineation of detailed mitigation plan

Biological Environment

* Assessment of flora and fauna present within the impact zone of the project

* Assessment of potential damage to terrestrial and aquatic flora and fauna due to discharge of effluents and gaseous emissions from the project

* Assessment of damage to terrestrial flora and fauna due to air pollution, and land-use and landscape changes

Biological Environment (Cont…)

* Assessment of damage to aquatic and marine flora and fauna due to physical disturbances and alteration

* Prediction of biological stresses within the impact zone of the project

* Presentation of proposed mitigation measures to prevent and /or reduce the damage

Land Environment

- Studies on soil characterization, existing land- use, land topography, landscape and patterns

  within the impact zone vegetation

* Estimation of impacts on land-use, landscape, topography and hydrology

* Identification of potential utility of treated WW in land application and subsequent impacts

* Estimation and characterization of solid wastes and delineation of management options for minimization of waste and environmentally compatible disposal

Socioeconomic and Health Environment

* Collection of demographic and related socio-economic data
* Collection of epidemiological data including studies on prominent endemic diseases (eg flourosis, malaria, etc.) and morbidity rates among the population within the impacted zone
* Projection of anticipated changes due to the project and delineation of measures to minimize impacts
* Assessment of historical and cultural impacts, including sites of archaeological significance
* Assessment of economic benefits arising out of the project

Environment Management Plan

- Delineation of mitigation measures including prevention and control for each environmental component

- Delineation of post project monitoring mechanism process to incorporate the unanticipated impacts and continuous environmental performance improvement systems

Environmental indices

: can be useful in accomplishing one or more of the following objectives :

- To summarize existing environmental data
- To communicate information on the quality of the affected (baseline) environment
- To evaluate the vulnerability or susceptibility of an environmental category
- To focus attention on key environmental factors
- To serve as a basis for the expression of impact by forecasting the difference between the pertinent index with the project and the same index without the project.

Pollutant Standard Index (PSI)

A common Pollutant Standard Index (PSI) should:

- Be easily understood by the public
- Include major pollutants and be capable of including future pollutants
- Relate to ambient air quality standard
- Be calculated in a simple manner using reasonable assumptions
- Be based on a reasonable scientific premises
- Be consistent with perceived air pollution levels
- Be spatially meaningful
- Exhibit day to day variation
- Enable forecasting in advance

Conceptual Limitations of EIA

* presently conceived merely as a project level tool and does not address to developmental programs at policy and planning level.
* constraints of existing policies and plans limit the range of possible alternatives in project
* project level EIA remained a reactive, quasi-regulatory instrument only.
* most appropriate stage for implementing EIA is at the level of district planning, since at this stage, a reasonable number of alternatives are available to the developer.

Conceptual Limitations of EIA (cont….)

- * assessment of regional supportive and assimilative capacities during formulation of development plans could greatly reduce the requirement for project EIA.
- * does not incorporate the strategies of preventive environmental interventions.
- * always conducted under severe limitations of time, manpower, financial resources and data.

Environmental Impact Assessment

End of Topic

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

- Environmental tasks, needing attention on sustained basis can be manifold

- May necessitate the need for a full fledged qualified Environment Manager

Tasks :

Promoting environmental consciousness & ideals throughout the company

- Identifying opportunities / scope for greening the company's product range.

- Introduction of eco-compatible technical measures

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

- Keeping abreast of latest eco-developments relating to all areas of the company's business & introducing them in the organization, whenever feasible
- Undertaking Life Cycle Studies & ensuring their introduction in new product development or project planning
- Assessing environmental protection costs
- Maintaining cost-benefit analysis data on regular basis
- Implementation of regulations/laws

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

- Establishing procedures & ensuring their implementations

- Setting up environmental information & control systems

- Planning & carrying out environmental audits

- Undertaking environmental training programs

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

- Ensuring that environmental issues form part of agenda at company meetings
- Undertaking environmentally beneficial projects in the society
- Involving employee families & children in eco-activities

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

- Providing inputs for environmental reporting
- Carrying out environmental PR work
- Identifying green business opportunities
- Spreading environmental concern through the supply & distribution chains

ENVIRONMENT MANAGER’S FUNCTIONS WITHIN AN ORGANIZATION

End of Topic

Environmental Accounting

Discussion

- Environmental Accounting Overview
  - What is environmental accounting
  - Why do environmental accounting
  - What is an environmental cost
- System Strategies
  - Reactive, Proactive, Leadership
- Business Purpose and Application
  - Example - Cost Allocation
- Methodologies

Environmental Accounting Overview

What is environmental accounting?

– A flexible tool to provide information not necessarily provided in traditional managerial systems.

Goal

- Goal of environmental accounting is to increase the amount of relevant data for those who need or can use it.
- “Relevant data ” depends on the scale and scope of coverage

Scale and Scope

- Applicable at different scales of use and scopes (types) of coverage.
  - **Application** at an individual process level (production line), a system, a product, a facility, or an entire company level.
  - **Coverage** (focus) may include specific costs, avoidable costs, future costs and/or social external costs

Scale and Scope

- Decisions on scale and scope of application significantly impact ability to assess and measure environmental costs
  - Process vs Facility
  - Discreet costs vs Hidden vs Contingent vs Image Costs

Why do Environmental Accounting ?

- Environmental cost can be significantly reduced or eliminated as a result of business decisions.
- Environmental costs may provide no added value to a process, system or product (i.e. waste raw material)
- Environmental costs may be obscured in general overhead accounts and overlooked during the decision making process.

Why do Environmental Accounting ?

- Understanding environmental costs can lead to more accurate costing and pricing of products.
- Competitive advantage with customers is possible where processes and products can be shown as environmentally preferable.

Environmental Costs

- Major challenge in application of environmental accounting as a management tool is identifying relevant costs.
- Cost definition determined by intended use of data (i.e. cost allocation, budgeting, product/process design or other management decision support).

Environmental Costs

- Types of Environmental Costs
  - *Conventional*: material, supplies, structure and capital costs need to be examined for environmental impact on decisions.
  - *Potentially Hidden*:
    - Regulatory (fees, licenses, reporting, training, remediation)
    - Upfront and back end (site prep, engineering, installation, closure and disposal)
    - Voluntary (training, audits, monitoring and reporting)
  - *Contingent*: penalties/fines, property liability, legal)
  - *Image*: Relationship with employees, customers, suppliers, regulators and shareholders

Overview Summary

- Flexible tool to provide relevant data not ordinarily captured in traditional systems.
- Successful application requires up-front understanding of scale and scope of application.
- Once identified, information needs to be communicated/distributed to decision makers and considered as a component of management’s decision making criteria

System Strategies

- Environmental Accounting systems typically fall into one of three categories:
  - Reactive
  - Proactive
  - Leadership

Reactive Systems

- Typically spread costs (capital and expense) across various overhead categories.
- Environmental costs typically not assigned to specific line/process or activity.
- Reactive system fails to provide indication or quantification of environmental costs.
- As a result it fails to identify cost drivers and minimizes opportunity to develop tactics to reduce these costs.

Proactive systems

- Costs are categorized and assigned to specific process and activities.
- Costs incurred can be identified, classified and quantified but are limited to discreet costs.
- Decisions typically focus on incremental activities (i.e. minimize waste, etc.).

Leadership Systems

- Includes both financial and non-financial issues in the relevant data used in the business decision process.
- Systems are designed to include value chain perspectives.
- Both the process as well as the product are evaluated for relationship between inputs and overall value provided to minimize "total costs".

Application

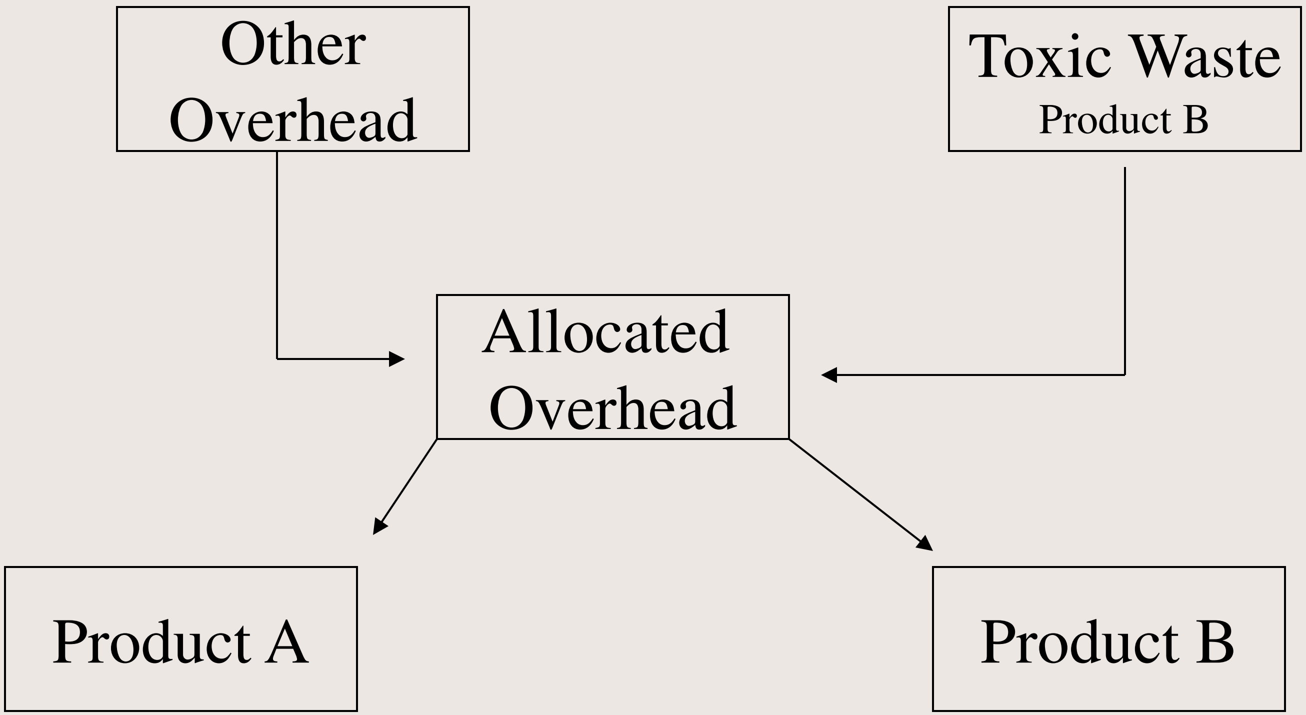
- Utilization of data generated from application of environmental accounting tool can be used for a variety of decision classes including:
  - Cost allocation
  - Capital budgeting
  - Product design

Cost Allocation

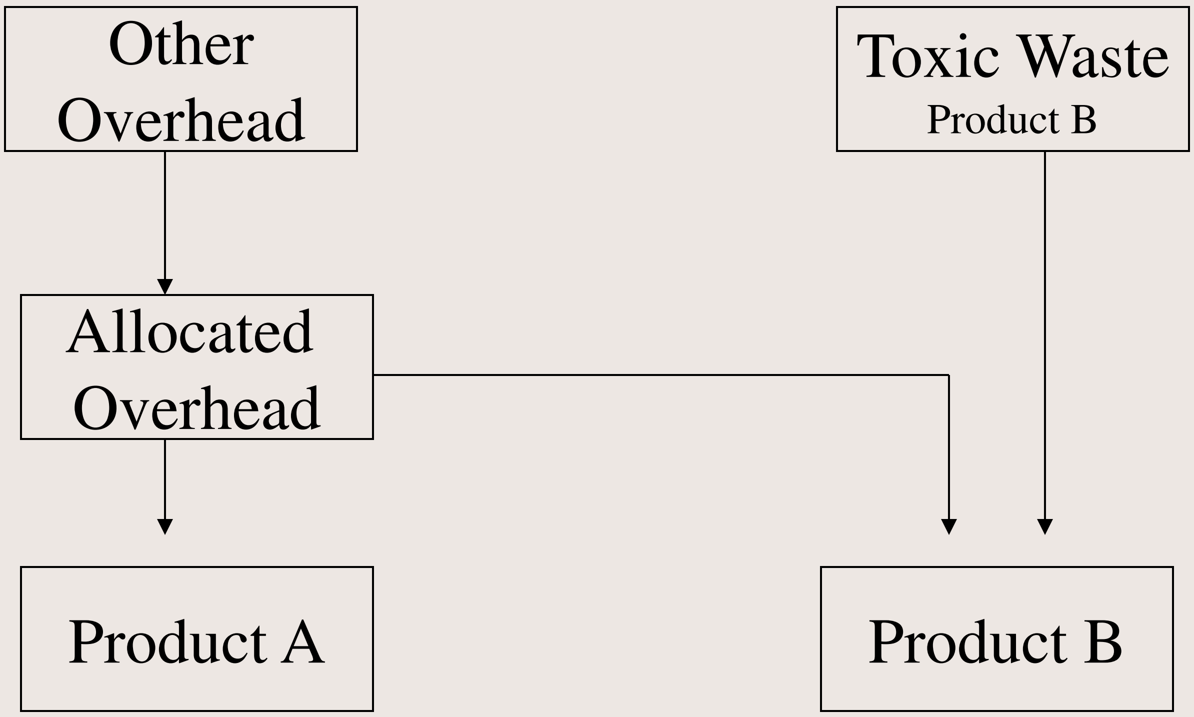
an example

- Goal - Bring environmental costs to attention of corporate stakeholders.
- Four steps in environmental cost allocation:
  – Determine scale and scope of the application
  – Identify environmental costs
  – Quantify those costs
  – Allocate those costs to responsible product, process or system

Traditional Cost System



Modified Allocation System

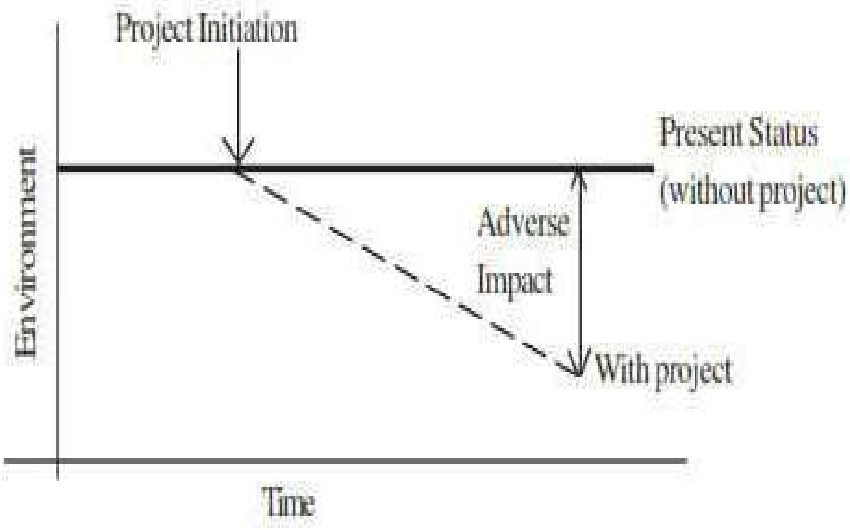


Methodologies

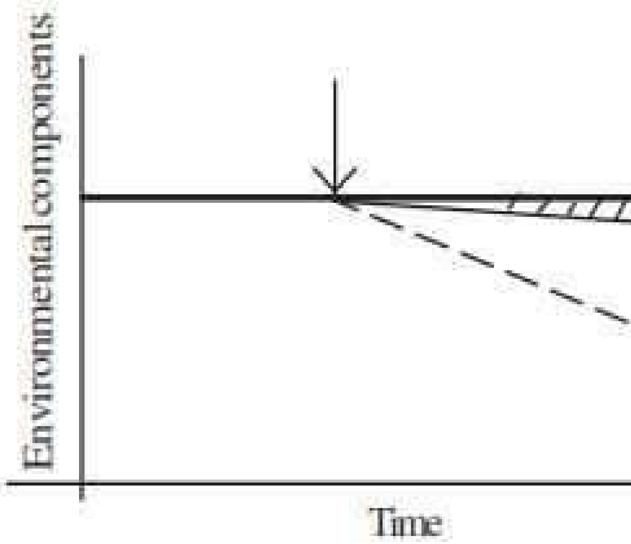
Related Accounting Topics

- Application of Environmental Accounting typically used in conjunction with:
  - Activity Based Costing (ABC)
  - Total Quality Management (TQM)
  - Business Process Re-engineering
  - Balanced Score Card

& EMP



Project Initiation
Present Status
(without project)
Adverse
Impact
With project
Environment
Time



Environmental components
Time

Environmental Impact Assessment (EIA)

Environmental Impact Assessment (EIA) is a process of evaluating the likely environmental impacts of a proposed project or development, taking into account inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse. (ref)

It aims to predict environmental impacts at an early stage in project planning and

Environment - Indian Scenario

- India is the first country to make provision and improvement of Environment (constitution 42nd Amendment)
- Empowers state to make provision for environment protection and improvement (directive principle of state policy in Chapter - IV, Article 48A)
- All citizen to protect and improve environment (fundamental duties Article 51Ag)

- After stockholm conference on Human Environment, 1972
  - Water Act (Prevention and Control Act), 1974
  - Formation of CPCB, State PCBs
  - Water (Cess) Act, 1977
  - Air Act (Prevention and Control), 1981
  - Environment Protection Act, 1986
  - On Jan 27th 1996, under EPA, 1986, GoI advised that all expansion or modernisation of any activity or new project should undergo EIA process for clearing particular project/activity (EIA Notification - http://envfor.nic.in/legis/eia/so1533.pdf).

Institutional Framework

Govt, of India

Ministry of Environment and Forest

Central Pollution Control Board

Zonal Office

State Govt

Dept. of Environment

State Pollution Control Board

Regional Office

Values of EIA process

- **Integrity** - objective, unbiased and balanced
- **Utility** - balanced, credible information for decision making
- **Sustainability** - should result in Environmental safeguard

Benefits of the EIA process ref

- Potentially screens out environmentally-unsound projects
- Proposes modified designs to reduce environmental impacts

- Identifies feasible alternatives
- Predicts significant adverse impacts
- Identifies mitigation measures to reduce, offset, or eliminate major impacts
- Engages and informs potentially affected communities and individuals
- Influences decision-making and the development of terms and conditions

Roles in the EIA process

The Project Proponent

- → Prepare the DFR (Detailed Feasibility Report)
- → DFR make available to public
- → Approach SPCB for NOC
- → Apply IAA for environmental clearance

The Environmental Consultants

- → Guide the Proponent and prepare EIA report
- → Supply environmental related information to SPCB and IAA
- → Justify the findings in the EIA & EMP with experts group of IAA

State PCBs/ Pollution Control Committee

- ➔ Responsible for assessing compatibility of the proposed development with current operational and prescribed standards
- ➔ Issues NOC
- ➔ Details of public hearing shall be forwarded to IAA

The Public

- ➔ The concerned persons will be invited through press advertisement to review the information for environmental clearance

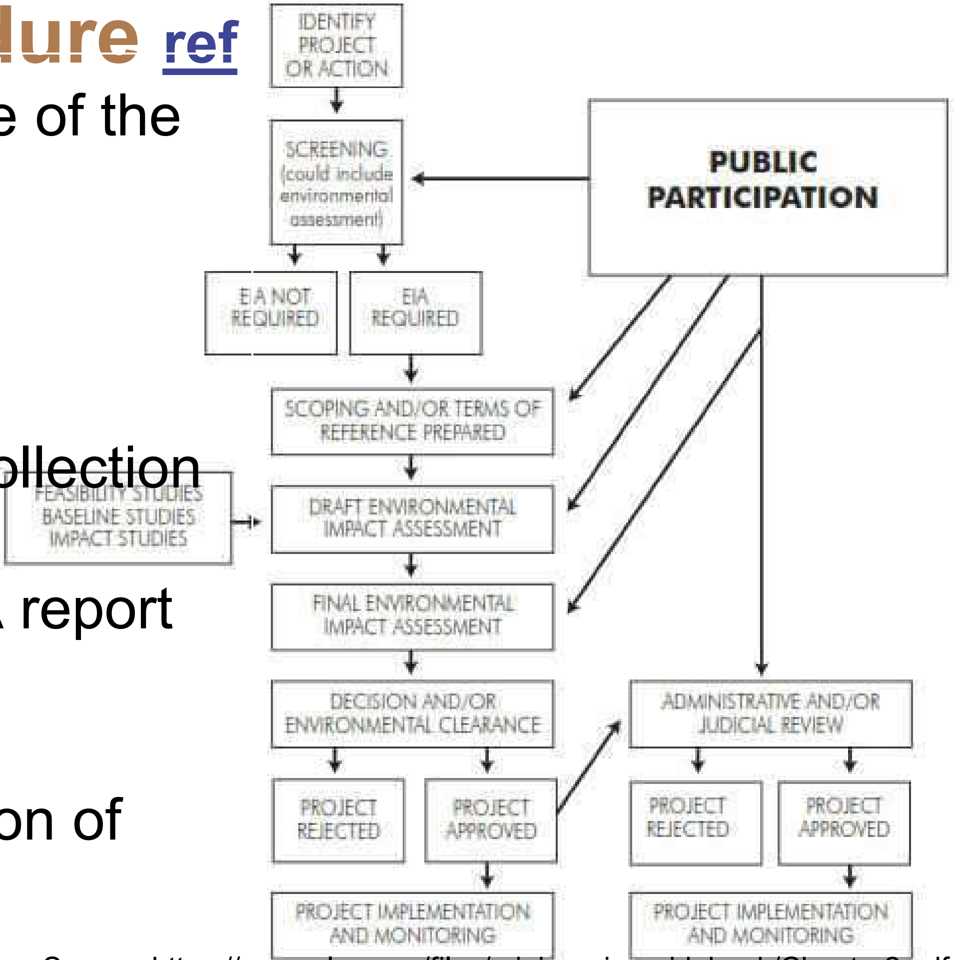
IAA

- → Evaluate and assess the EIA report
- → Set of recommendations and conditions for implementing the accepted project
- → Sets of conditions made available to public
- → Monitor the implementation and operational phase of the project

EIA - Cycle and Procedure ref

The EIA process in India is made of the following phases

- ➔ Screening
- ➔ Scoping
- ➔ Collection of baseline data collection
- ➔ Impact prediction
- ➔ Mitigation measures and EIA report
- ➔ Public hearing
- ➔ Decision making
- ➔ Monitoring and implementation of EMP



Source: https://www.elaw.org/files/mining-eia-guidebook/Chapter2.pdf

Screening: screened for scale of investment, location and type of development and if the project needs statutory clearance.

Scoping: The project's potential impacts, zone of impacts, mitigation possibilities and need for monitoring done by EIA agency by following the published guidelines by the Ministry of Environment and Forest (MoEF) of government of India

Collection of baseline data: Baseline data is the environmental status of study area.

Impact prediction: Positive and negative, reversible and irreversible and temporary and permanent impacts need to be predicted for environmental components (Air, Noise, Water, Land, Biological Socioeconomic, Solid Waste)

Mitigation measures and EIA report: Actions and steps for preventing, minimizing or by passing the impacts or level of compensation for probable environmental damage or loss.

Public hearing: Public and environmental groups living close to project site may be informed and consulted.

Decision making: IAA along with the experts consult the project-in-charge along with consultant to take the final decision, keeping mind EIA and EMP

Monitoring and implementation of environmental management plan: The various phases of implementation of the project are monitored.

Risk assessment: Inventory analysis and hazard probability and index also form part of EIA procedures

Environmental Management Plan ref

EMP should include

- Delineation of mitigation and compensation measures
- Delineation of unmitigated impacts
- Physical planning including work program, time schedule and locations for mitigation and compensation
- Delineation of financial plan

The management plans should be necessarily based on considerations of resource conservation and pollution abatement

Liquid Effluents

- Effluents from the industrial plants should be treated well to the standards as prescribed by the Central/State Water Pollution Control Boards.
- Soil permeability studies should be made prior to effluents being discharged into holding tanks or impoundments and steps taken to prevent percolation and groundwater contamination.

- Special precautions should be taken regarding flight patterns of birds in the area.Effluents containing toxic compounds,oil and grease have been known to cause extensive death of migratory birds.Location of plants should be prohibited in such type of sensitive areas.
- Deep well burial of toxic effluents should not be resorted to as it can result in re-surfacing and groundwater contamination.Re-surfacing has been known to cause extensive damage to crop and livestocks.
- In all cases,efforts should be made for re-use of water and its conservation.

Air Pollution

- The emission levels of pollutants from the different stacks,should conform to the pollution control standards prescribed by Central or State Boards.
- Adequate control equipment should be installed for minimising the emission of pollutants from the various stacks.
- In-plant control measures should be taken to contain the fugitive emissions.

- Infrastructural facilities should be provided for monitoring the stack emissions and measuring the ambient air quality including micro-meteorological data (wherever required) in the area.
- Proper stack height as prescribed by the Central/State Pollution Control Boards should be provided for better dispersion of pollutants over a wider area to minimise the effect of pollution.
- Community buildings and townships should be built up-wind of plant with one-half to one kilometer greenbelt in addition to physiographical barrier.

Solid Wastes

- The site for waste disposal should be checked to verify permeability so that no contaminants percolate into the groundwater or river/lake.
- Waste disposal areas should be planned down-wind of villages and townships.
- Reactive materials should be disposed of by immobilising the reactive materials with suitable additives.
- The pattern of filling disposal site should be planned to create better landscape and be approved by appropriate agency and the appropriately pretreated solid wastes should be disposed according to the approved plan.

- Intensive programs of tree plantation on disposal areas should be undertaken.

Noise and Vibration

- Adequate measures should be taken for control of noise and vibrations in the industry.

Occupational Safety and Health

- Proper precautionary measures for adopting occupational safety and health standards should be taken.

Housekeeping

- Proper house-keeping and cleanliness should be maintained both inside and outside of the industry.

Prevention,maintenance and operation of Environment Control Systems

- Adequate safety precautions should be taken during preventive maintenance and shutdown of the control systems.
- A system of inter-locking with the production equipment should be implemented where highly toxic compounds are involved.

Vegetal Cover

- Industries should plant trees and ensure vegetal cover in their premises.This is particularly advisable for those industries having more than 10 acres of land.

Transport Systems

- Proper parking places should be provided for the trucks and other vehicles by the industries to avoid any congestion or blocking of roads.
- Siting of industries on the highways should be avoided as it may add to more road accidents because of substantial increase in the movements of heavy vehicles and unauthorised shops and settlements coming up around the industrial complex.

- Spillage of chemicals/substances on roads inside the plant may lead to accidents.Proper road safety signs both inside and outside the plant should be displayed for avoiding road accidents.

Recovery - reuse of waste products

- Efforts should be made to recycle or recover the waste materials to the extent possible.The treated liquid effluents can be conveniently and safely used for irrigation of lands,plants and fields for growing non-edible crops.

Disaster Planning

- Proper disaster planning should be done to meet any emergency situation arising due to fire,explosion,sudden leakage of gas etc.Fire fighting equipment and other safety appliances should be kept ready for use during disaster/emergency situation including natural calamities like earthquake/flood.

Environment Management Cell

- Each industry should identify within its set up a Department/Section/Cell with trained personnel to take up the model responsibility of environmental management as required for planning and implementation of the projects.

Environmental Impact Assessment

- “ Environmental Impact Assessment ’’ (EIA) is the quantitative estimate of select parameters that reflect the quality of environment and natural systems before, during, and after the proposed action. It can be defined as the systematic identification and evaluation of the potential impacts (effects of proposed projects, plans, programs, or legislative actions relative to the physical chemical, biological, cultural and socio-economic components of total environment.

EIA

- **Primary impacts**
- **Secondary impacts**

Impacts resulting from proposed actions can be placed in one or more of the following categories :

- 1. Beneficial or detrimental
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- 7. Local, regional, national or global
- 8. Accidental or planned (recognized beforehand)
- 9. Direct (primary)

EIA

- **Effects or Impacts**
  - Direct effects
  - Indirect effects
- **Cumulative impacts**
- **Environmental Inventory**
  - Physical Chemical Environment
  - Biological Environment
  - Socioeconomic Environment
  - Biophysical Environment
  - Natural Environment
- **Environment Impact Statement (EIS)**

Impact Prediction

- Air - total emissions
  - changes in ambient levels and ground level concerns
  - effects on climate, soils, material, vegetation and human health
- Water - availability of supply
  - changes in quality
  - sediment transport
  - effects to groundwater
  - surface and groundwater quality
- Land - changes in land use
  - changes in land quality
- Biota - changes in existing numbers of terrestrial plants and animals
  - effects on existing numbers of terrestrial plants and animals
  - effects of contaminants
  - effects on rare & endangered species, endemic species, migration path
- Socio - impacts on the community
- Economic- effects on economic status
  - effects on health

EIA

- **Assessment of Alternatives and delineation of mitigation measures**

- **Post Project Monitoring and Auditing**

Essential elements of EIA

- Comprehensive and Rapid
- Rapid EIA one season data collection, Review of Rapid EIA
- Submissions must, therefore focus on the following outcome

- A decision that the proponent does not need to submit a comprehensive EIA or

- A decision that the proponent does need to submit a comprehensive

- EIA including informing the proponent of its required forms

* ENVIRONMENTAL MANAGEMENT *

Anand Pendharkar
Director, SPROUTS

* SESSION: 1

WHY SHOULD WE BE CONCERNED ABOUT THE ENVIRONMENT ?

WHY SHOULD <u>WE</u> BE CONCERNED ABOUT THE ENVIRONMENT ?

- **Reason: 1 MORALISTIC VIEW**

impact of human activity on earth unparalleled in terms of destruction of species. Life on earth has evolved over a period of 3000 million years and man obviously had no contribution to it. All other species live in harmony with their surroundings, so why should man be different? Each species has a right to live. Right to live, in turn, implies a right to the environment in which they evolved and in which they can live.

WHY SHOULD <u>WE</u> BE CONCERNED ABOUT THE ENVIRONMENT ?

- **Reason: 2 GAIA HYPOTHESIS**

"Organisms have evolved with the physical environment to zrovide an intricate control system that keeps earth's conditions favourable for life" 'life on earth is supported by life on earth itself.' the earth was no different from the other planets to begin with. life began on earth 3 billion years ago, its atmosphere contained nitrogen, ammonia, hydrogen, carbon monoxide, methane & water vapour, but no free oxygen. also chlorine & hydrogen sulfide.

WHY SHOULD WE BE CONCERNED ABOUT THE ENVIRONMENT ?

Reason: 2 GAIA HYPOTHESIS

Lack of oxygen meant lack of ozone in the earth's atmosphere hence no protection from the UV rays of the sun, which can damage & destroy the DNA.

advent of photosynthesis led to the release of oxygen oxygen built-up, it generated O3 The moment vegetation moved to the surface, it started growing rapidly, When the green cover & the host of fauna it supports vanishes, the earth will not support any life form -including human.

WHY SHOULD WE BE CONCERNED ABOUT THE ENVIRONMENT ?

- Reason: 3 **WEB OF LIFE**

everything in nature is linked to each other in many complex ways ~ man has little or no knowledge.

WHY SHOULD WE BE CONCERNED ABOUT THE ENVIRONMENT ?

- **Reason: 4 INADEQUACY OF HUMAN UNDERSTANDING OF ENVIRONMENTAL PROCESS**

- Environmental study as a science has evolved only during the last 40 years
- CFCs / DDT

WHY SHOULD WE BE CONCERNED ABOUT THE ENVIRONMENT ?

- Albert Swietzer

" Whenever I injure life of any sort, I must be quite clear whether it is necessary. Beyond the unavoidable, I must never go, not even with what seems insignificant. The farmer who has mown down a thousand flowers in his meadow as fodder for his cows, must be careful on his way home not to strike off in wanton pastime the head of a single flower by the roadside, for he thereby commits a wrong against life, without being under the pressure of necessity."

WHY SHOULD WE BE CONCERNED ABOUT THE ENVIRONMENT ?

We are not being truly civilized if we concern ourselves only with the relationship of man to man; what is important is the relationship of man to all life ~" a relationship that is essentially one of reverence for all living things ~ plants, animals, wilderness, people, a relationship that leads to a life in harmony with nature.“

* SESSION: 2

‘ HUMAN ACTIVITY & ITS IMPACT ON ENVIRONMENTAL PROCESSES '

HUMAN ACTIVITY & ITS IMPACT ON ENVIRONMENTAL PROCESSES

- **Ozone Layer Depletion:**

  ozone layer was formed over a period of 300 crore years. in less than a 100-year time over 10% of this ozone has got destroyed. hole in the Antarctic ozone layer. ~ larger than the European continent. each 1 percent drop in ozone will increase the incidence of human skin cancer by 3 to 6% And who knows the extent of damage this is causing to other life forms?

HUMAN ACTIVITY & ITS IMPACT ON ENVIRONMENTAL PROCESSES

Green House Effect

Excessive burning of fossil fuels destruction of forests, increasing livestock, manmade waste projected consequences melting of polar ice caps increase in sea level, submerging many coastal cities decreased yields of fish, expansion of desert areas, disruption of agricultural system

HUMAN ACTIVITY & ITS IMPACT ON ENVIRONMENTAL PROCESSES

Acid Rain:

nitrous and sulphur oxides react with moisture in the atmosphere to form acids brought down by the rains as acid rains. huge damages to forests to property

HUMAN ACTIVITY & ITS IMPACT ON ENVIRONMENTAL PROCESSES

Contamination of Oceans: Excessive use of pesticides, insecticides, herbicides, fertilizers heavy metals and oils (spilled or drained) release of sewage in oceans. decline in fish catch leads to increase in dependence on land grazing animals for meat supply. means destruction of rain forests for conversion into grazing areas, added use of fertilizers, And the circle of damage grows.

HUMAN ACTIVITY & ITS IMPACT ON ENVIRONMENTAL PROCESSES

Destruction of Rain Forests: >60% of the new drugs in coming century will originate from plants. the rain forests of the world contain more than half of the earth's organic species are the single largest contributor to maintaining of the CO2 balance of the earth, are rapidly vanishing. We owe it to the generations to come, heritage handed to us for safe-keeping, to be finally passed on to posterity.

* SESSION: 3

‘Evolution of the Green Movement and its changing face’

‘Evolution of the Green Movement and its changing face’

The Varta Battery Case

THE PORTABLE BATTERY IS NOT A VERY ENVIRONMENTALLY FRIENDLY PRODUCT

~ During its manufacture, an average battery consumes 7 times the energy it can finally store In disposal, it releases harmful metals like lead, cadmium & mercury into the environment

‘Evolution of the Green Movement and its changing face’

The Varta Battery Case

SO WHY USE IT ?

~ it satisfies the need for 'power on the move' ~ like for stereos, Walkmans, cameras & flashlights (though it stayed on to power even stationery objects like transistor~radios & wall clocks) it is a big business

'Evolution of the Green Movement and its changing face'

The Varta Battery Case

BATTERY MARKET IN UK IN LATE 80s:

~

Eveready & Duracell held 60 % share of the market

~ Other 40% held by over a dozen other players

~ Share of the largest European manufacturer Varta, Germany, less than 4%

VARTA WAS DESPERATE TO INCREASE ITS MARKET SHARE.

‘Evolution of the Green Movement and its changing face’

The Varta Battery Case

EXPENSIVE MARKET RESEARCH ADVISED VARTA :

~ to introduce 'easy to open' packaging (as a major consideration amongst female users)

~ back it up by heavy sales promotion.

THE RESULT WAS A FRACTIONAL INCREASE IN MARKET SHARE.

.

‘Evolution of the Green Movement and its changing face’

The Varta Battery Case

‘INTERNAL DEVELOPMENT’

Varta launches a mercury~ free zinc chloride battery in Germany

‘Evolution of the Green Movement and its changing face’

The Varta Battery Case

‘EXTERNAL DEVELOPMENTS’

~Mrs. Margaret Thacher's speech to Royal Society

~ publication of Green Consumer Guide had started a wave of environmental concern in England

~The Green Consumer Guide strongly recommended a mercury-free

‘Evolution of the Green Movement and its changing face’

The Varta Battery Case

- **VARTA’S RESPONSE IN UK:**
- Varta had their mercury-free battery on the shop shelves in UK in 4 weeks time
- when 6 months later Eveready launched its own mercury-free, Varta responded by bringing out the cadmium-free battery
- the green product was backed by green marketing campaign
- early sales growth was the result of very favourable media coverage

‘Evolution of the Green Movement and its changing face’

The Varta Battery Case

~ followed by sponsorship of the Green Awards by the Grocer

~ introduction of packaging made of recycled paper card & degradable plastic

_ launch of an innovative return & recycle scheme where consumers were offered cash incentive for recycling.

~ tripling of distribution base

‘Evolution of the Green Movement and its changing face’

The Varta Battery Case

RESULTS :

Between mid-1988 and end-1989 raised Varta's market share in UK rose from less than 4% to 15%. 300% growth of market share in just 18 months!

‘Evolution of the Green Movement and its changing face’

TABLE-1

60's

(I) Publication of Rachel Carsen's `Silent Spring' (1962)

(II) Emergence of Environmental Economics as a separate branch of environment

(III) Publication of Paul Ehrlich's `The Population Bomb'

‘Evolution of the Green Movement and its changing face’

70's

(IV) Publication of Club of Rome's 'Limits to Growth' (1971)

(V) First Earth Summit --> establishment of United Nations Environmental Programme(UNEP).

First Earth Day (1972)

(VI) Formation of United States National Environmental Protection Agency (EPA)

(VII) Oil Crises (1974) and 'energy conservation' as a ajor international public issue.

(VIII) OEDC establishes the principle of `Polluter Pays‘

(IX) Trichlorophenol release at Soveso (1970)

‘Evolution of the Green Movement and its changing face’

80's

(X) Introduction of 'environmental audit' by large companies.

(XI) Dioxin release at Soveso (1983)

(XII) Emergence of Greenpeace & Friends of the Earth

(XIII) Shift from 'zero growth' to 'sustainable growth'

(XIV) Methyl Isocyanate release at Bhopal (1984)

(XV) Introduction of environmental assessment regulation by the

'Evolution of the Green Movement and its changing face'

_(XVI) Ozone hole comes out in the open (1985)

(XVII) Chernobyl disaster (1986)

(XVIII) Introduction of environmental audit in North America

(XIX) Montreal Protocol on CFC reduction

(XX) Environmental Assessment Directive introduced across Europe (1988)

(XXI) Exxon Valdez disaster in Alaska

(XXII) Emergence of 'sustainable development' as guiding principle of

‘Evolution of the Green Movement and its changing face’

90's

(XXIII) Agreement on phase-out of ozone depleting substances (1990).

(XXIV) Introduction of environmental audit in Europe & formation of European Environmental Agency

(XXV) GATT report on world free trade & environmental issues

(XXVI) Rio Earth Summit (1992)

* SESSION: 4

Environmental Accounting:

Environmental Accounting

Plant A manufactures chemicals.

Revenue

Sales of Goods	:-	a

Expenditure

Cost of direct inputs	:-	b
Overheads	:-	c
Financial Expenses	:-	d
Depreciation	:-	e

Environmental Accounting

- Plant B uses air for burning coal in its boiler.
- Plant C operates a big cooling tower Plant D needs air for instrumentation system. Plant E wants to start new construction manufacturing process of A generates acidic fumes CONSEQUENCES
- Plant B's boiler tubes get corroded & explosion occurs.
- Plant C's cooling water becomes acidic.

Environmental Accounting

Plant D's piping system gets damaged & its instruments stop functioning.

Plant E has to use special materials & special protective coatings

Situation (i): Plant A is part of a big manufacturing complex owned by a large company~ X.

Will X have to load its final products for the extra costs it incurs at B,C,D,E or no?

Situation (ii): This is an industrial estate where A, B, C, D, etc. are different companies.

Environmental Accounting:

What should happen? *Situation (iii):* Plant A is a manufacturing company

B, C, D, E are not manufacturing units but comprise A's general environment.

Acid rains damage to tree in Europe in early 90's was estimated at Rs.60,000 crores.

estimates of cost of clean-up of sites contaminated by hazardous chemicals & metals were estimated at Rs.20,000 crores.

The cost of healthcare due to pollution around the world will be a staggering amount beyond our imagination

Environmental Accounting:

The basic tenets of environmental accounting :

(i) Conventional accounting equates the cost of natural resources to the cost of acquiring these resources and totally ignores the cost of the consequences. (ii) Only those natural activities or products, which have immediate market value for man, are taken into consideration.
Other environmental processes and products are ignored. (iii) The environment is not something 'external' to a human activity, but part of it.

Environmental Accounting

Consequently the cost of restoration of the environment due to the human activity must become a part of the costs of that activity. (iv) The environmental capital is undervalued in comparison to financial capital. (v) Valuation of the land does not take into account the environmental services, which the land provides. At most, the market value of the resources on the land is taken into account.

(vi) Nature should be treated as capital rather than resource, when capital is destroyed the future of the whole activity which it supports is in endangered.

Environmental Accounting:

(vii) It is wrong to presume that all economics & economic activity is intended to service only mankind (viii) Preservation of environment & economic activity are not necessarily incompatible concepts. It is possible to generate income while preserving natural capital base. **<u>Valuation of the Environment:</u>**

How do we value the environment?

How would you value your own life?

~By the net discounted value of the salary you are going to earn in your lifetime?

~Or by the value of your utility to the society

~ Or by the value of old age security your existence offers to your parents?

~ Or by the joy you are giving to your family or friends?

Environmental Accounting:

classical definition of NDP:

NDP = Value of Consumption (A) + Value of all Investments (B) + Value of Net Export

(Private + Public) (C)

NDP = A + B + C + Value of production of nature collected (such as fuel-wood) + Value of environmental amenities provided by environmental resource stocks (such as clean air, etc.) + Value of leisure enjoyed + Value of addition to environmental resources stocks (clean air, etc.) + Value of additions to natural capital stock (such as forests) + Value of additions to stock of defensive capital (such as Air Pollution Control System, Sewage Treatment Systems, etc.)

(the so-called defensive expenditures -such as medical expenditure needed to fight the effect of pollution, are not deducted here).

‘`REVERENCE FOR LIFE'

Green House Effect/ Global Warming

PRODUCTION: Life Cycle means the cradle to grave story of any object through three major stages in life cycle:

-birth -existence

-death

Hindu mythology believed in three powers to govern the processes of:

-Creation

-Sustenance

-Destruction

industry initially occupied itself with only first two of the ab[...] processes. production & servicing

‘`REVERENCE FOR LIFE'

Green House Effect/ Global Warming

Production

- rudimentary rules regarding pollution during production stage

Usage

- Rachael Carson’s ‘Silent Spring’
- Ralph Nader’s crusade against the automobile manufacturers
- discovery of the ozone hole

Disposal

- damage to the earth’s environment by manmade waste In Business terms:

-Evolution stage

-Functional stage

‘`REVERENCE FOR LIFE'

Green House Effect/ Global Warming

Earlier: **cost & convenience** aspects of the first two stages only

Now : **cost, convenience** & additionally the aspect of **compatibility** (with environment) **for all 3 stages**

To ensure that their product creates least negative impact on the environment through its birth, life and in death.

Environmental concerns will be the driving force for technological innovation in the 21st century

‘`REVERENCE FOR LIFE'

Green House Effect/ Global Warming

Life span of a typical product :

Evolution Process : 0 –2 years

Functional Life : 2-30 years

Dissolution Time : 5 - 60 years

Environmental Considerations in Product Life Cycle Study

-Resources include not only raw materials, but also energy inputs & also the production facilities including buildings.

-The process of acquisition or collection of these resources, itself, must be also environmentally friendly.

-Environmentally friendly manufacturing involves minimum consumption of resources, minimum wastage, minimum waste generation & minimum emissions.

Environmental Considerations in Product Life Cycle Study

-Environmentally friendly logistics would involve minimum handling & movement of products, minimum usage of resources in storage, minimum emissions or waste generation in logistics process, etc.

-Environmentally friendly packaging materials include not only the materials used in packaging but also inks used in printing etc.

Environmental Considerations in Product Life Cycle Study

--Minimization of environmental impacts during use implies lower resource usage (like power, water, material, etc), lesser emissions & wastage generation, etc. during usage.

Each of these aspects or areas can have cascading effect

Each aspect or area can become

RENEWABLE VS NON-RENEWABLE RESOURCES

-Renewable resources characteristics:

-replenishment at an appreciable rate

-nature will maintain their stock (if natural mechanism not appreciably damaged by anthropogenic activity)

Solar energy

Drinking Water

Availability of food from land & sea

Non-renewable & depletable resources

RENEWABLE VS NON-RENEWABLE RESOURCES

-Limits to Growth

- need to control the extraction & consumption

- to ensure their efficient allocation over a very long period of time

FACTORS INFLUENCING DEMAND & AVAILABILITY OF DEPLETABLE RESOURCES:

-The cost of extraction of a depletable resource will increase with time (all else being same)

ENVIRONMENT IMPACT ASSESSMENT

Concept of Environmental Impact

- Role /Need of EIA
- Indian policies requiring EIA
- Screening/ scoping in the EIA process
- Essential elements of EIA
- Detailed activities in an EIA
- Environmental Evaluation System
- Environmental Impact Statement

Environmental Impact Assessment

- effects of proposed projects, plans, programs, or legislative actions
- relative to the physical chemical, biological, cultural and socioeconomic components of total environment
- quantitative estimate
- before, during, and after the proposed action
- systematic identification and evaluation of the potential impacts **Environmental Impact**

Environmental Impact Assessment

Environmental Impact- any alteration of environmental conditions or creation of a new set of environmental conditions

- effects on the resource base

Primary Impacts

- project "inputs" generally cause primary impacts
- attributed directly to the proposed action
- primary impacts are generally easier to analyze and measure

Environmental Impact Assessment

Secondary Impacts

- Secondary impacts are indirect or induced changes
- indirect or induced changes,
- typically include the associated investments and changed patterns of social and economic activities likely to be stimulated or induced by proposed action.
- also included would be any planned increase in growth rate or level
- secondary impacts are usually more difficult to measure

In the biophysical environment, the secondary impacts can be especially important.

Environmental Impact Assessment

Impacts resulting from proposed actions can be placed in one or more of the following categories :

1. Beneficial or detrimental
2. Naturally reversible or irreversible
3. Repairable via management practices or irreparable
4. Shot term or long term
5. Temporary or continuous
6. Occurring during the construction phase or the operational phase
7. Local, regional, national or global
8. Accidental or planned (recognized beforehand)
9. Direct (primary)

Environmental Impact Assessment

Effects or Impacts :

- may include growth inducing impacts and other impacts related to induced changes in the pattern of land-use, population density or growth rate and related effects on air, water and other natural systems, including ecosystems
- effects may be ecological, aesthetic, historic, cultural, economic, social or health related, whether direct, indirect or cumulative.
- may have both beneficial and detrimental effects

Environmental Impact Assessment

1) Direct Effects / Impacts :- caused by the action and occur at the same time and place

2) Indirect Effects / Impacts:- caused by the action but later in time or further removed in distance, yet reasonably foreseeable

3) Cumulative Impacts: - incremental impact of the action when added to the other past, present and reasonably foreseeable future actions,

- regardless of what agency
- can result from individually minor, but collectively significant actions

Environmental Inventory

- complete "description of the environmental setting without the project"compiled from a checklist of descriptors for the physical-chemical, biological, cultural, and socioeconomic environments

- "Physical Chemical Environment" - includes such major areas as soils, geology, topography, surface water and ground water resources, water quality, air quality and climatology.

- "Biological Environment" – include flora and fauna of the area, including species of tress, grasses, insects fish, reptiles, birds and mammal with special emphasis on the endangered.

Environmental Inventory

- "Cultural Environment" ~ include historic and archaeological sites and aesthetic resources such as visual quality
- "Socioeconomic Environment"~ includes population trends and distribution, economic indication of human welfare, educational system, transportation networks and other infrastructure concerns such as water supply, wastewater disposal, and solid waste management, public services. etc.
-
- Earlier only technical & economic factors dominated the decision making process.
- Now also environmental, social &other factors.

Environmental Inventory

An Idealist * Approach to EIA.

- Apply to all projects that are expected to have significant environmental
- impacts and address all impacts that are expected to be significant
- Compare alternatives to a proposed project (including possibility of non development of site)
- Result in a clear EIS which conveys the importance of the likely impacts and their specific characteristics to non experts as well as experts
- Include broad public participation and stringent administration review procedures
- Be timed so as to provide information for decision making
- Be enforceable
- Include monitoring and feedback procedures

Environmental Inventory

The Need for EIA

- Due to benefits
- Government policies requiring EIA

Environmental Inventory

Benefits of EIA :

- helps to ensure that development options under consideration are sustainable
- helps to foresee potential problems likely from a proposed development and address them in the project planning and design stage
- can enable the incorporation of improvements and mitigation measures in a project's development
- can prevent future liabilities or costly alternatives in project design.
- can generate alternate routes for development process technologies and project sites

Environmental Inventory

~ establishes qualitative values for parameters indicating the quality of environmental activity, thus allowing measures that ensure environmental compatibility

presents a clear and concise picture of all costs and benefits associated with alternative causes of action

~ provide a mechanism for merging the concerns for environment and economics in the process of decision making

~ can provide guidelines for developmental activities in the context of regional carrying capacity

Environmental Inventory

Indian Policies Requiring EIA:

Environment (Protection) Act on May 23,1986, which provides a legislative framework for

* Protection and improvement of the environment
* Implementation of India's commitments relating to the protection and improvement of the environment, and prevention of hazards to human beings, other living creatures and property; ratified under the United Nations Conference on Human Environment (June 1972). To achieve the above objectives, a notification of EIA was issued on Jan.27,1994 and amended in May, 1994 and April, 1997. The latest amendment has introduced public hearing into the EIA process.

Environmental Inventory

Situations where EIA is required in India:

* Any new project as in Schedule I

* Pollution loads are increased through the expansion or modernisation. ~ is a way of 'mapping' the environmental consequences of the significant aspects of the projects and its alternatives

~ element of uncertainty is always present when making predictions

~ impacts should be determined for Air, Water, Land, Biota and the Socio~economic environment.

Environmental Inventory

Air ~ total emissions

~ changes in ambient levels and ground level concerns

~ effects on climate, soils, material, vegetation and human health

Water ~ availability of supply

~ changes in quality

~ sediment transport

~ effects to groundwater

~ surface and groundwater quality

Land ~ changes in land use

~ changes in land quality

Environmental Inventory

Biota ~ changes in existing numbers of terrestrial plants and animals

~ effects on existing numbers of terrestrial plants and animals

~ effects of contaminants

~ effects on rare and endangered species, endemic species, migration path

Socio ~ impacts on the community

Economic ~ effects on economic status

~ effects on health

Environmental Inventory

Assessment of Alternatives and delineation of mitigation measures

~various alternatives are identified and compared from an environmental perspective

~a mitigation plan is drawn which is supplemented with an EMP to guide the proponent towards on going environmental improvement.

Post Project Monitoring and Auditing

~carried out during the construction and operation of a project

~to observe that during that project operation the prediction and agreements of EIS are complied with.

~ where impacts exceed those predicted, action should be taken.

Detailed activities in an EIA :

Environmental Inventory

Air Environment

- Determination of impact zone an monitoring network
- Determination of existing status of ambient air quality within the impacted region (7~10) km radius of the proposed plant
- Collection of surface meteorological data viz, wind speed, direction, humidity, temperature and lapse rate
- Estimation of air emissions
- Identification, quantification and evaluation of other potential emissions within the impact zone and estimation of cumulative emissions

Environmental Inventory

- Prediction of changes in ambient air quality through appropriate model
- Evaluation of the adequacy of the proposed pollution control devices to meet gaseous emission and ambient air quality standards
- Delineation of suggested mitigation measures at source, pathways and receptor

Environmental Inventory

Noise Environment

* Assessment of the present status of noise levels within the impact zone and prediction of future noise levels resulting from the project
* Prediction and evaluation of impacts due to any anticipated rise in noise levels on the surrounding environment
* Recommendations on mitigation measures for noise pollution

Environmental Inventory

Water Environment

* Study of existing ground and surface water resources with respect to its quantity and quality within the impact zone of the proposed project
* Prediction of impacts on water resources due to the proposed water use by the project
* Assessment of the WW quantity and characterization including toxic or organic, and proposed effluent quantities
* Evaluation of the proposed pollution prevention and WW treatment system and suggestions on modification, if required
* Prediction of impacts on the quality of the receiving water body using appropriate mathematical/simulation models
* Assessment of the feasibility of water recycling and reuse and delineation of detailed mitigation plan

Environmental Inventory

Biological Environment

* Assessment of flora and fauna present within the impact zone of the project
* Assessment of potential damage to terrestrial and aquatic flora and fauna due to discharge of effluents and gaseous emissions from the project
* Assessment of damage to terrestrial flora and fauna due to air pollution, and land-use and landscape changes
* Assessment of damage to aquatic and marine flora and fauna due to physical disturbances and alteration
* Prediction of biological stresses within the impact zone of the project
* Presentation of proposed mitigation measures to prevent and/or reduce the damage

Environmental Inventory

Land Environment

* Studies on soil characterization, existing land-use, land topography, landscape and patterns within the impact zone vegetation
* Estimation of impacts on land-use, landscape, topography and hydrology
* Identification of potential utility of treated WW in land application and subsequent impacts
* Estimation and characterization of solid wastes and delineation of management options for minimization of waste and environmentally compatible disposal

Environmental Inventory

Socioeconomic and Health Environment

* Collection of demographic and related socio-economic data
* Collection of epidemiological data including studies on prominent endemic diseases (eg flourosis, malaria etc.) and morbidity rates among the population within the impacted zone
* Projection of anticipated changes due to the project and delineation of measures to minimize impacts
* Assessment of historical and cultural impacts, including sites of archaeological significance
* Assessment of economic benefits arising out of the project

Environmental Inventory

Environment Management Plan

* Delineation of mitigation measures including prevention and control for each environmental component
* Delineation of post project monitoring mechanism process to incorporate the unanticipated impacts and continuous environmental performance improvement systems

Environmental Inventory

Environmental indices can be useful in accomplishing one or more of the following objectives :

- ~ To summarize existing environmental data
- ~ To communicate information on the quality of the affected (baseline) environment
- ~ To evaluate the vulnerability or susceptibility of an environmental category
- ~ To focus attention on key environmental factors
- ~ To serve as a basis for the expression of impact by forecasting the difference between the pertinent index with the project and the same index without the project

Environmental Inventory

A common Pollutant Standard Index (PSI) should :

- ~ Be easily understood by the public
- ~ Include major pollutants and be capable of including future pollutants
- ~ Relate to ambient air quality standard
- ~ Be calculated in a simple manner using reasonable assumptions
- ~ Be based on a reasonable scientific premises
- ~ Be consistent with perceived air pollution levels
- ~ Be spatially meaningful
- ~ Exhibit day to day variation
- ~ Enable fore casting in advance

Environmental Inventory

Conceptual Limitations of EIA :

* presently conceived merely as a project level tool and does not address to developmental programmes at policy and planning level.
* constraints of existing policies and plans limit the range of possible alternatives in project
* project level EIA remained a reactive, quasi-regulatory instrument only.
* most appropriate stage for implementing EIA is at the level of district planning, since at this stage, a reasonable number of alternatives are available to the developer.

Environmental Inventory

assessment of regional supportive and assimilative capacities during formulation of development plans could greatly reduce the requirement for project EIA.

* does not incorporate the strategies of preventive environmental interventions.
* always conducted under severe limitations of time, manpower, financial resources and data.

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

~ Environmental tasks, needing attention on sustained basis can be manifold

~ may necessitate the need for a full fledged qualified Environment Manager

Tasks :

Promoting environmental consciousness & ideals throughout the company

~ Identifying opportunities / scope for greening the company's product range.

~ Introduction of eco-compatible technical measure

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

~ Keeping abreast of latest eco-developments relating to all areas of the company's business & introducing them in the organization, whenever feasible

Undertaking Life Cycle Studies & ensuring their introduction in new product development or project planning

~ Assessing environmental protection costs

~ Maintaining cost-benefit analysis data on regular basis

~ Implementation of regulations/laws

~ Establishing procedures & ensuring their implementations

~ Setting up environmental information & control systems

~ Planning & carrying out environmental audits

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

- Undertaking environmental training programmes
- Ensuring that environmental issues form part of agenda at company meetings
- Undertaking environmentally beneficial projects in the society
- Involving employee families & children in eco-activities
- Providing inputs for environmental reporting
- Carrying out environmental PR work
- Identifying green business opportunities
- Spreading environmental concern through the suppl
distribution chains

Overview

- Quick overview of what this meeting is all about
  - Agenda
  - What to expect

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

~ECO-FRIENDLY ORGANIZATION

The course an organization should follow to become an eco-friendly organization:

(i) commit itself to the establishment of an environmental management system;

(ii) conduct an initial review & assessment of the organization's environmental position concerning its environmental policy & adherence to environmental standards;

(iii) formulate an environmental policy in the form of a corporate environmental programme (basis of a state of target and objectives for company's environmental management system);

ENVIRONMENT MANAGER'S FUNCTIONS WITHIN AN ORGANIZATION

- (iv) complete an inventory of the organization's activities, and an assessment of their environmental impact, in relation to the stated policy;
- (v) study the pertinent regulations & requirements to ensure compliance;
- (vi) develop an environmental management plan and a supporting manual which details all the relevant aspects of the system;
- (vii) apply the management plan in both the company's operations & record keeping;
- (viii) maintain a cycle of audits of the company's performance to test whether objectives & targets are [illegible] met.

Source: The British Standard BS7750 for 'Environmental Management System'

ENVIRONMENTAL MANAGEMENT : INTRODUCTION & SCOPE

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M.Sc. 4th semester

What is Environment ?

- The sum total of all surroundings of a living organism, including natural forces & other living things which provide conditions for development & growth as well as of danger & damages.

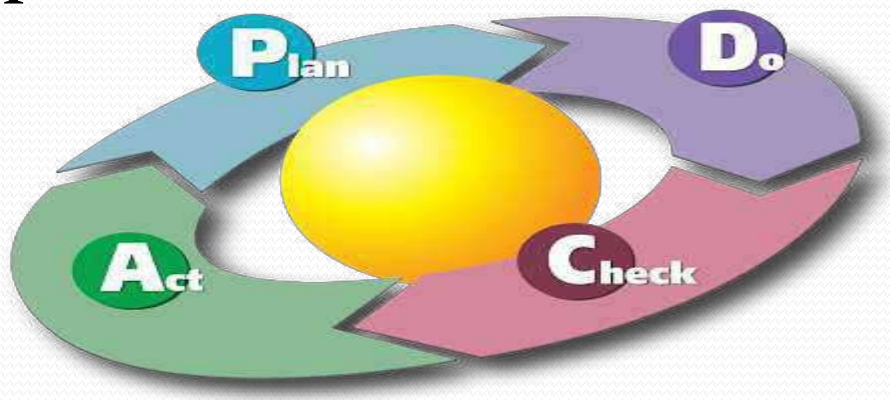
INTRODUCTION

- The science of Environment studies is a multi-disciplinary science.
- It is the science of physical phenomena in the environment.
- It is a broad field of study that includes also the natural environment, built environment and the sets of relation between them.
- Our very survival in this planet earth depends on the proper management of environment.
- Every living being are interdependent directly or indirectly.

- The climatic condition depends on the air, temperature. Everyone is now feeling the change of climate due to the rise in air temperature of the earth.
- More presence of CO_2 is resulting ozone layer depletion & acid rain.
- Due to enormous increase in population & stress on environmental factors like air, water & soil, it is now urgently needed to frame guidelines & rules for the management of environment in a proper way.
- A good management of environment can only bring a sustainable life to all in this planet earth.

ENVIRONMENTAL MANAGEMENT

- **DEFINITION** – **"Environmental management system refers to the management of an organization's environmental programs in a comprehensive, systematic, planned and documented manner. It includes the organizational structure, planning & resources for developing, implementing and maintaining policy for environmental protection."**



EMS Model

CHARECTERISTICS OF EM

Environmental management supports sustainable development

Environmental management demands the multi-disciplinary approach. It deals with a world affected by humans.

Environmental management has to integrate different development view points.

Environmental management seeks to integrate natural and social science.

Environmental management can extend from short-term to long- term and from local to global level.

TWO MAIN STANDARDS

- The British Standard Institute's

i. BS7750- 'Specification for environmental management systems' (BS11994 & The international standards organization's draft

ii. ISO 14001 – Environmental management systems'(ISO 1995)

TWO SCHEMES OF EM

- The **Eco-Management and Audit scheme(EMAS)** – established by the European commission in 1993.
- It enables organization to assess, manage & continuously improve their environmental performance.
- The scheme is globally applicable and open to all types of private and public organizations.
- Currently more than 4,600 organizations & more than 7,900 sites are EMAS registered.

WHY HAVE AN EMS?

- Improve management of environmental impacts
- Set targets to reduce energy use, water use & waste to landfill
- Initiate and maintain procedures to improve efficiencies including:
  - Environmentally friendly purchasing procedures
  - Preferred business travel option
- Define key responsibilities for achieving targets
- Monitor and measure environmental performance against key indicators
- Regularly assess progress towards achieving set objectives
- Ensure due diligence and ongoing consideration of legal and other environmental requirements

WHY HAVE AN EMS?

- Assist with environmental reporting as required by s.516A of the EPBC Act 1999
- Government policy encourages commonwealth agencies to implement an EMS (at least one site)
- Contribute to preferred employer status
- Achieve cost savings
- Show leadership, nationally or internationally
- Obtain competitive advantage
- May be required by clients, customers or regulators
- Build goodwill from customers, employees and stakeholders

SCOPES OF EM

- The awareness regarding environmental problems and their proper management began in 1970s through various people movement around many countries of the world.
- The Green peace movement, The Chipko movement etc. are some of them.
- The advancement in the field of science and technology helped to provide various tools and instrument supported by statistical data to properly solve environmental problems and help in its management.

The broader scopes of environmental management includes;

- To identify the environmental problem and to find its solution.
- To restrict & regulate the exploitation & utilization of natural resources.
- To regenerate degraded environment & to renew natural resources(renewable)
- To control environmental pollution & gradation.
- To reduce the impacts of extreme events & natural disaster.
- To make optimum utilization of natural resources.
- To assess the impacts of proposed projects & activities on environment.

- The scopes in the following areas need environmental management;

1. Population increase and health services.
2. Treatment of pollutants (air, water & solid) generated from various sources.
3. Pollution level in air water & soil.
4. Development of non-polluting renewable energy sources like wind, solar, biomass etc.
5. Solid waste utilization through recycling.
6. Biodiversity conservation
7. Environmental awareness in society.

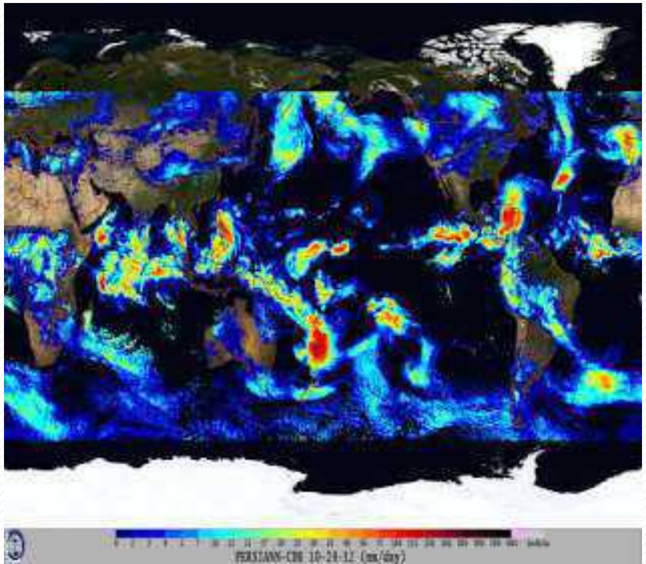
IMPORTANCE OF EMS

- An EMS addresses the environmental impact of an organization's activities & establishes goals and procedures that will improve the impact it has on the environment and human health.

1. Federal compliance – Clean Water Act, clean Air Act, & the Toxic substances control Act.
2. Public health
3. Emergency planes
4. Compliance
5. Reduce costs
6. Environmental ethic
7. Awareness

ROLE OF REMOTE SENSING IN EM

- Environmental monitoring – Deforestation, Watershed protection, Species inventory, Forest health & vigor
- Geological application – Bedrock mapping, Litho logical mapping, Structural mapping, Geobotany, Geo-hazard mapping, Planetary mapping.
- Urban mapping applications
- Hydrological applications
- Water pollution control
- Coastal ecosystem management – Mangroves management



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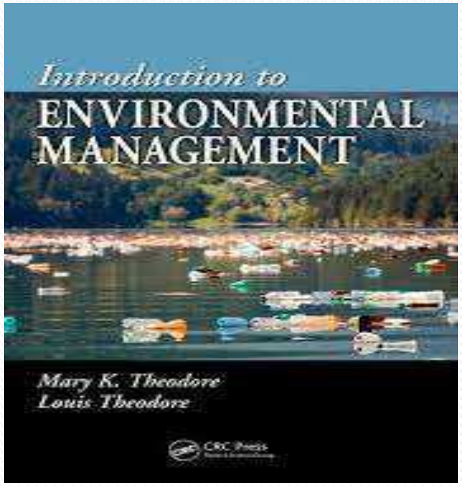
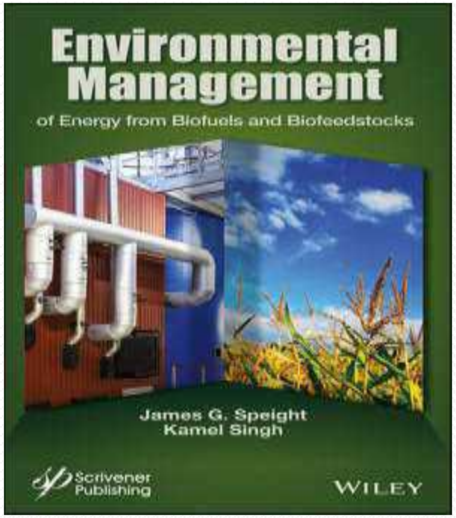
- Environmental management
  - James G. Speight
  - Kamel Singh
- Introduction & scope of environmental management Wikipedia, the free encyclopedia





THANK YOU

Green Business, Ecolabelling

Green Business ref

- Sustainable business, or green business, is an enterprise that has minimal negative impact on the global or local environment, community, society, or economy
- A sustainable business is any organization that participates in environmentally friendly or green activities to ensure that all processes, products, and manufacturing activities adequately address current environmental concerns while maintaining a profit.

- It incorporates principles of sustainability into each of its business decisions.
- It supplies environmentally friendly products or services that replaces demand for nongreen products and/or services.
- It has made an enduring commitment to environmental principles in its business operations

Green business pillars ref

Recycling and waste reduction	· Reduce · Reuse · Recycle · Upcycle · Separate waste · Dispose in a suitable way
Energy and water Conservation	· Save heat and electricity use · Save water use · Use efficient equioment · Use only when needed source from renewable energy sources
Pollution prevention	· Use low emission equipment · Operate efficiently · Use degradable packaging
Green procurement	· Produce environmentally sustainable and local materials/ products · Choose suppliers based on sustainable principles
Green distribution	· Avoid transport to long distances · Use the most sustainable method of transport · Choose distributors based on sustainable principles
Green after sales service	· Avoid transport to long distances · Use the most sustainable method of transport · Choose distributors based on sustainable principles
	· Productive work · Fair income · Security in the workplace · Social protection · Personal development · Social intergration · Participation · Equality of opportunity and treatment for all women and men.

Source: http://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/publication/wcms_424963.pdf

- Eliminate or decrease the environmental harm caused by the production and consumption of their goods

- Profit of the organizations share with community

- Economical benefits to the workers, community

Source: http://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/publication/wcms_424963.pdf

Paaduks (http://www.paaduks.com/)

Paaduks engages cobblers in producing eco-friendly footwear with soles made from scrap tyres. The footwear is simple, stylish, durable and environment-friendly. The initiative was aimed to empower local cobblers and artisans by engaging them in the recycling and reusing of tyres to produce footwear and earn revenues from the business. There are dual objective served here, uplifting social and economic status of cobblers and impacting carbon footprint by recycling used tyres.

Social Benefits: The profits made by Paaduks are used in providing better healthcare for the Cobblers', their families, and education for their children.

Economic Benefits: Paaduks pays cobblers almost three times as much as other wholesalers and retailers in the market. The initiative augments incomes of needy communities and improves their quality of life.

Environmental Benefits: Production of footwear created through reuse and recycled scraped tyres reduce soil pollution and dumping of waste in landfills.

Source: http://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/publication/wcms_424963.pdf

Six essential characteristics of Green Business ref

1. Triple top-line value production - *financial benefits for the company, natural world betterment, and social advantages for employees and members of the local community*

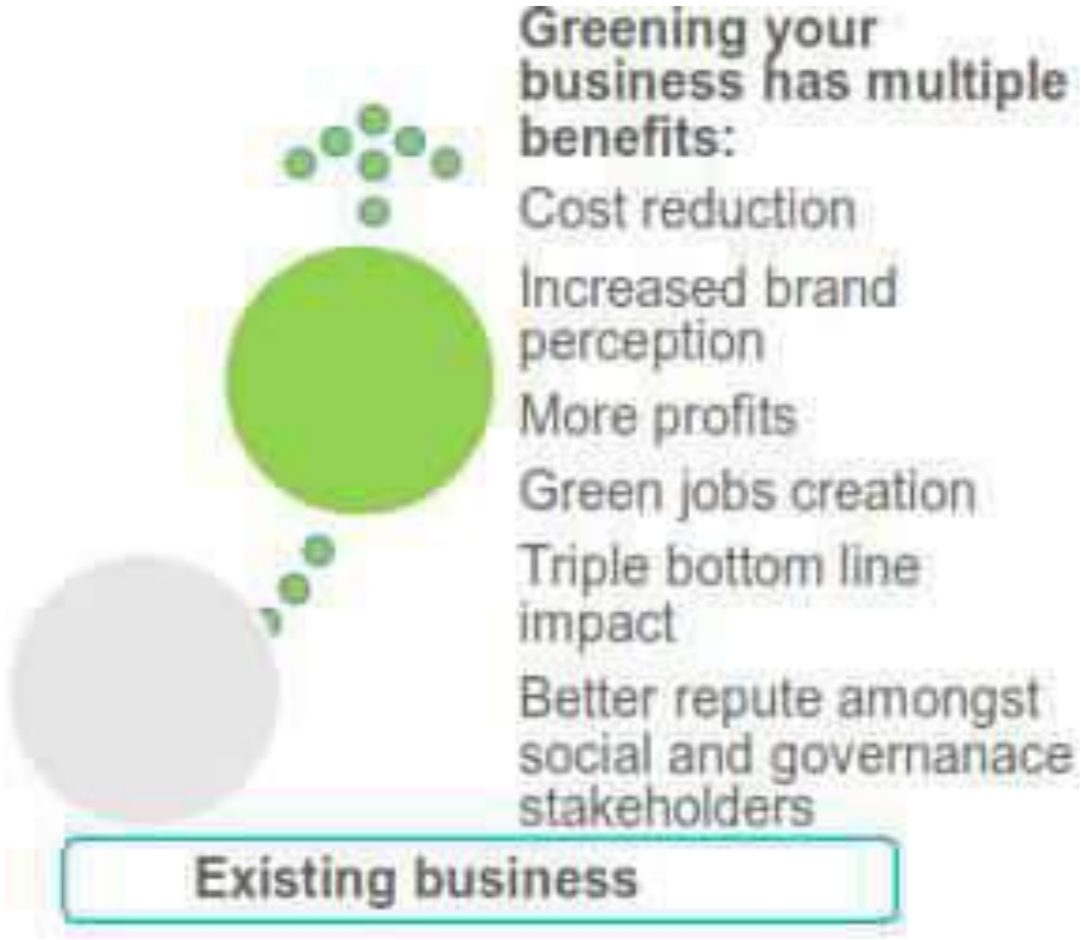
2. Nature-based knowledge and technology - *biomimicry-based principal involves the conscious emulation of natural-world genius in terms of growing our food, harnessing our energy, constructing things, conducting business healing ourselves, processing information and designing our communities*

3. Products of service to products of consumption - *Products of service are durable goods routinely leased by the customer that are made of technical materials and are returned to the manufacturer and re-processed into a new generation of products when they are worn out.*

4. Solar, wind, geothermal and ocean energy - *employing only sustainable energy technology—solar, wind, ocean and geothermal—that can meet our energy needs indefinitely without negative effects for life on earth.*

5. Local-based organizations and economies - *This ingredient includes durable, beautiful and healthy communities with locally owned and operated businesses and locally managed non-profit organizations, along with regional corporations and shareholders working together in a dense web of partnerships and collaborations*

6. Continuous improvement process - *The continuous process of monitoring, analyzing, redesigning and implementing is used to intensify TTL value production as conditions change and new opportunities emerge*



Extra Resources

1. Green Business Model Innovation
2. Sustainable Business Case Studies
3. Little Green Bags: True Business Sustainability
4. Business Case for Sustainability

Source: http://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/documents/publication/wcms_424963.pdf

Ecolabelling

- The concept of Ecolabelling is to encourage environmentally friendly commodities in the market.
- Ecolabelling was first introduced in Germany in 1978.
- It enforce the companies to develop products and processes having lesser environmental impact.
- In 1991, GoI launched its first eco-label, known as 'Eco-mark' through Central Pollution Control Board (CPCB),

- GoI that follows a cradle-to-grave approach (from raw material extraction, to manufacturing, and to disposal).
- It advocates pro-active and promotional roles of the consumers, the industry, and the government at one platform to address environmental protection issues and to implement environmental protection strategy

- Eco-label acts as a qualifying criterion for companies for improved environmental management to ensure long term stewardship and availability of natural resources for a nation’s sustainable growth.

Source:
https://www.google.co.in/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwiV4sW
IqMfWAhXFJZQKHdafDBUQjRwIBw&url=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FEcomark&psig=AFQjC
NFKTYLJJpS9m2a1bOu0tH2FkUVJRg&ust=1506668527290677

Criteria for Ecomark

The following primary environmental criteria for products are prescribed:

- ★ that they cause substantially less pollution than other comparable products in production, usage and disposal;
- ★ that they are recycled and/or recyclable where comparable products are not;
- ★ that their price is not extraordinarily higher than comparable products; and

- ★ that they make a significant contribution to saving non-renewable resources or minimizing use of renewable resources compared with other comparable products;
- ★ that they contribute to a reduction of adverse environmental health consequences;
- ★ that they comply with laws, standard and regulations pertaining to the environment.

Extra Resources

1. Introduction to Ecolabelling
2. https://www.globalecolabelling.net/what-is-eco-labelling/
3. http://www.ecospecifier.com.au/knowledge-green/technical-guides/technical-guide-9-introduction-to-ecolabels-and-environmental-product-declarations.aspx

A Systems Approach to Waste Management

Dr. Nikhil K. Kothurkar

Outline

- Motivation
- Conventional Approach
- Systems Approach: Principles for Optimizing the Waste Management Method
- Example: Simple vs. Complex Systems
- Amplify Benefits
- Waste Disposal Priorities
  - Plastic Waste
  - Dry Biomass
  - Human Waste
  - Animal Waste
  - Organic Waste
- Towards a Sustainable Home

- Solid Waste generated in Indian cities and towns:
  - In 1947 was 6 million tonnes
  - In 1997 about 48 million tonnes

India's Solid Waste Problem

- More than 25% of the municipal solid waste is not collected at all!
- 70% of the Indian cities lack adequate capacity to transport it
- There are no sanitary landfills to dispose of the waste
- ~50% of municipal solid waste is organic in nature (potential manure/compost).

What an inheritance to leave for our children!

Where do you think our milk comes from? Oops! Do our kids drink this stuff?

Ram Teri Ganga Maili Ho Gayi!

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Conventional Approach

CHANGE OF ATTITUDE TOWARDS WASTE

- Waste is not waste. It is merely a misplaced resource
- It can be converted to manure, energy or other products.
- But for it to be used as a resource, it has to be separated

There is no waste in Nature. Nature converts, recycles and reuses all wastes. The waste of one organism is the food of another.

Waste Management Case Study:
Amrita Vishwa Vidyapeetham Campus, Coimbatore

Before 2008, campus waste was deposited by residents in the waste bins without segregation....

Which recycler will accept soiled paper or plastic for recycling?

Problems with Dumping of Mixed Wastes

- **Health hazard** to waste pickers and sorters: Bad odour and the risk of infection
- **Socially Demeaning** and objectionable to sort through personal sanitary wastes and food waste, which are mixed with all the other waste.
- **Inefficient Recycling:** Many recyclable items cannot be recycled since they are heavily soiled
- **Environmental Damage:** Soiled recyclables have to be buried or incinerated leading to environmental damage.
- Sorting is a tedious and labor intensive process

A Responsible Waste Management Strategy

- Waste can potentially be **a boon or a bane** depending upon the ***management strategy.***
  - **Boon**: it can yield energy, reusable materials, raw material for processes.
  - **Bane:** environmental damage and pollution, disease and health problems.
- Separate wastes at source (every house). Try to reuse at source, whenever possible.
- Collect different categories of waste and transport to central sorting center.
- Further sort into several categories at the sorting center.
- Find markets for selling the various categories of sorted wastes.
- Minimize exposure of workers to hazardous and offensive conditions

Waste Segregation at Source

- In 2008, waste segregation at source was implemented.
- In common areas, four categories of bins were placed.
- Bins for different categories were provided to residents, within their house.
- Training of campus residents, staff and house-maids was conducted.

SEPARATION AND BIN COLOR CODING
(AMRITA ETTIMADAI CAMPUS)

Organic/Food waste	**kitchen waste, food leftovers, vegetables, flowers, leaves, fruits.**
Recyclables	Only **dry paper, plastics**, carry bags, etc.
Sanitary Waste	Personal and hospital waste such as sanitary pads, cloth or bandages soiled with blood and other body fluids.
Other waste	**Milk pouches**, ***badly soiled paper and plastic, coconut shells,*** glass, metals, foil, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish, tubelights, old medicines.


Sintex
NAPKIN
WASTE
FOOD
WASTE
Sintex
NAPKIN WASTE
நாப்கின் கழிவுகள்
FOOD WASTE

AMRITA RECYCLE CENTER (ARC)

Further Manual Sorting of Waste

AMRITA HAS MADE A DIFFERENCE

- Every bit of waste on campus is collected and taken to the **Amrita Recycle Center (ARC).**
- Manual sorting of wastes
- Organic (food) waste is composted: manure for orchards
- Recylables are recycled
- Non-recyclabes are incinerated
- Effluent treatment plant for campus liquid effluent.

True to the teachings of Amma, we take responsibility for protecting Nature and our fellow-humans

RESULT

- A clean campus, free from litter and pollution.
- Organic gardens and orchards
- Protection of the environment
- Recycling of paper, plastics, scrap metal, glass and other recyclables

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Systems Thinking

- Systems thinking is necessary for solving interconnected problems.
- The WHOLE is more than just the sum of the individual PARTS.
  - E.g. Putting together all the parts of a car in any random order does not make a functional car.
  - Each part is related to other parts in a specific way and contributes to the functioning of the whole.
  - Design is necessary both at the component level and the system level. (e.g. each part must be properly designed and the entire car must also be properly designed.)
  - Diagnosing and correcting malfunctions in complex and interrelated problems requires systems thinking.

  - Watch this video **Systems thinking: an introduction** (3.31 min)
  - Systems thinking: a cautionary tale (cats in Borneo) (3.08 min)

Systems Approach

- Select the **best** among the several possible waste management strategies
    - Integrating solid waste management with gardening, milk production, water management and energy systems, can give ***very high returns***.
    - Complex systems can give higher resource use efficiency but at a higher infrastructure and maintenance cost
    - Optimization is necessary.

Principles for Optimizing the Waste Management Method

- Segregate waste at source
- Collect spoilable (organic) waste from sources twice a day.
- Tertiary seggregation at the collection center
- Reuse is better than Recycle
- Use each type of waste for the highest value application first.
- Use the same materials as many times as possible for relatively lower value applications each time.

Principles for Optimizing the Waste Management Method

- Convert wastes into value-added products
  - e.g. organic waste to compost for gardening.
- Amplify the benefits drastically by:
  - Including microorganisms, plants, small and large animals in the method.
  - Integrating waste management with food and energy production and water management.
- Balance between the high long term benefits of complex systems and the low immediate infrastructure cost of simple systems.
- Beware of introducing or cycling toxins or pathogens in the human food chain.

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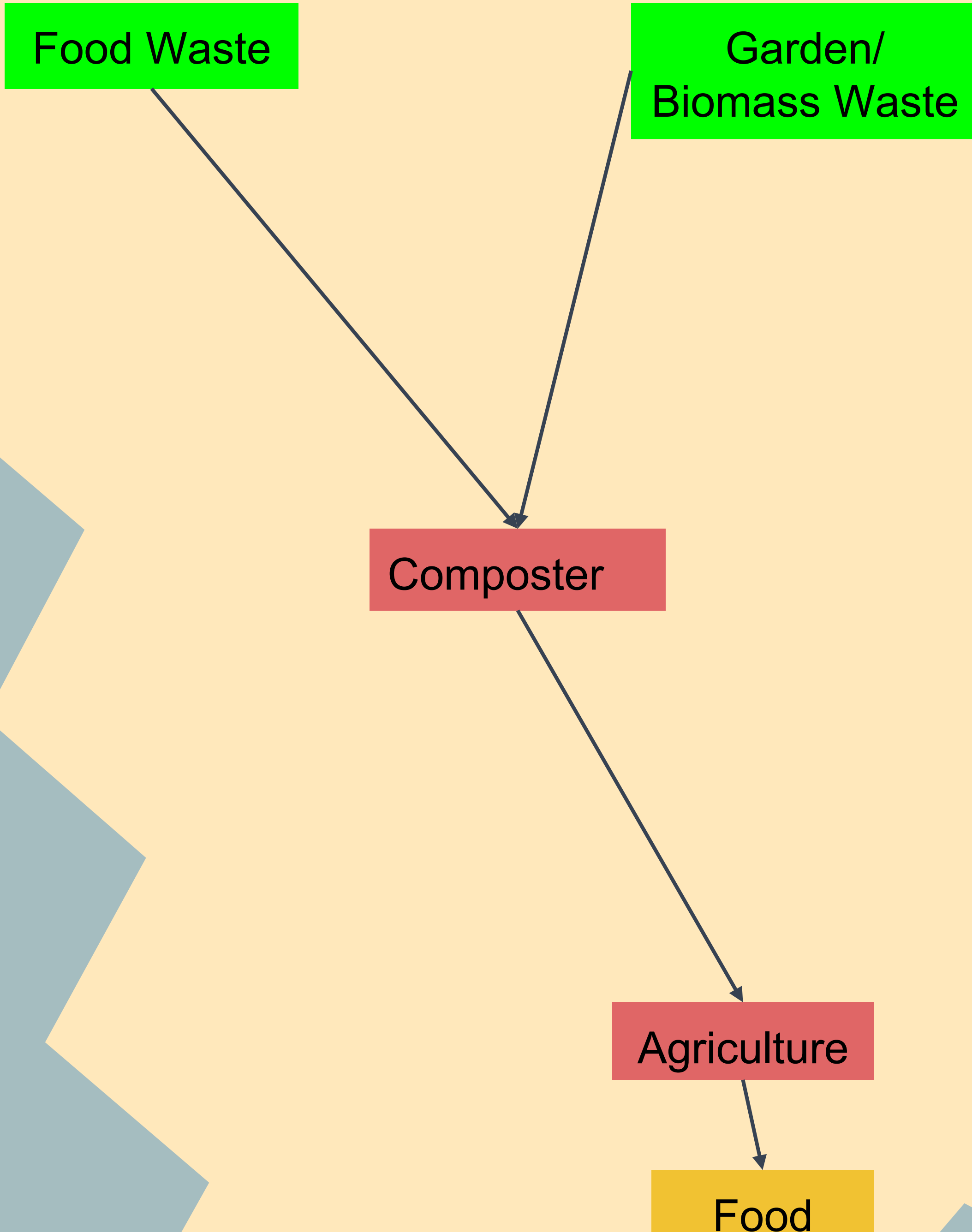
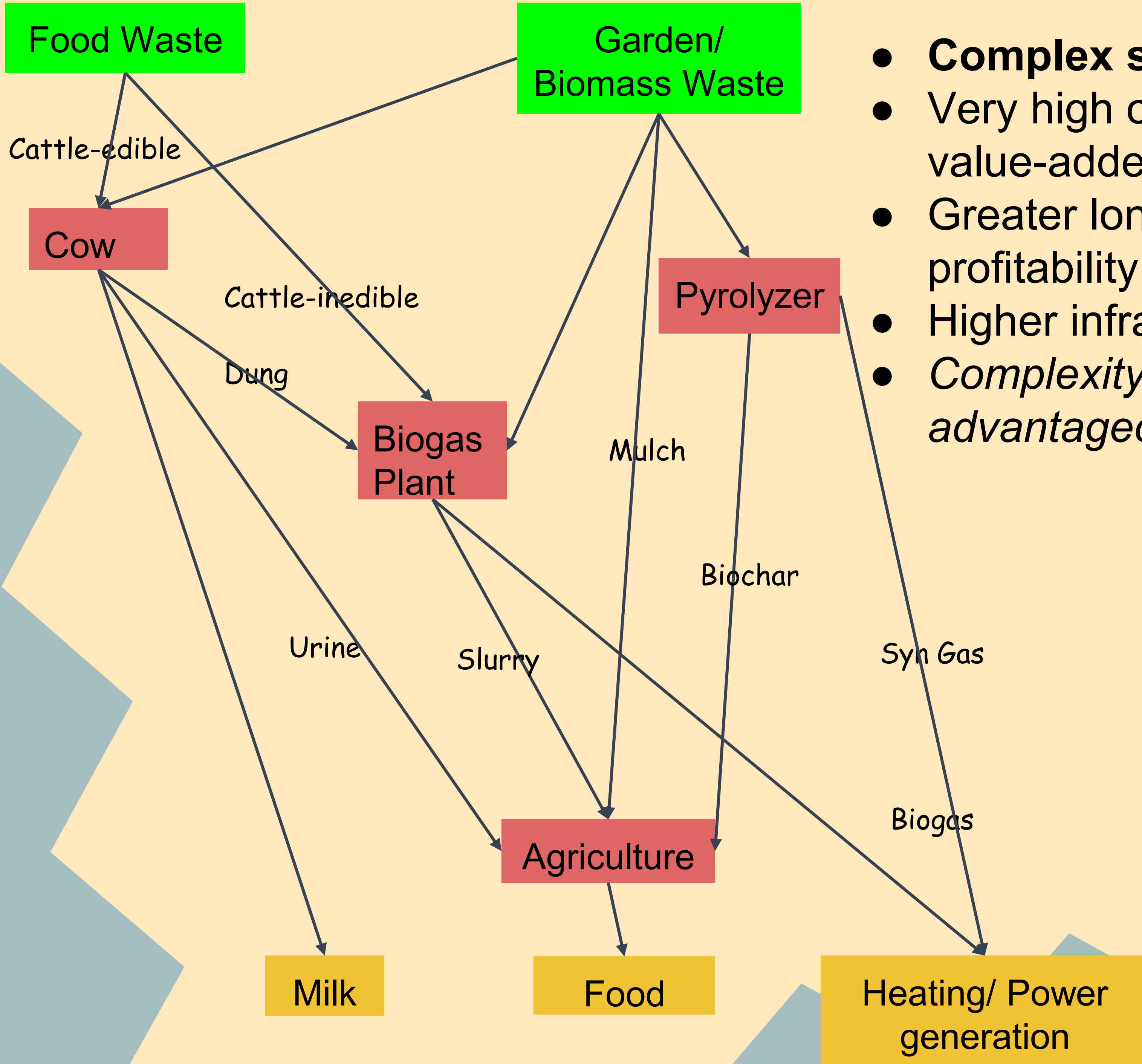


- **Simple system**
- Low output of value-added products
- Lower infrastructure
- Lower long-term profitability



- **Complex system**
- Very high output of value-added products
- Greater long-term profitability
- Higher infrastructure
- *Complexity is not always advantageous*

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Amplify the Benefits

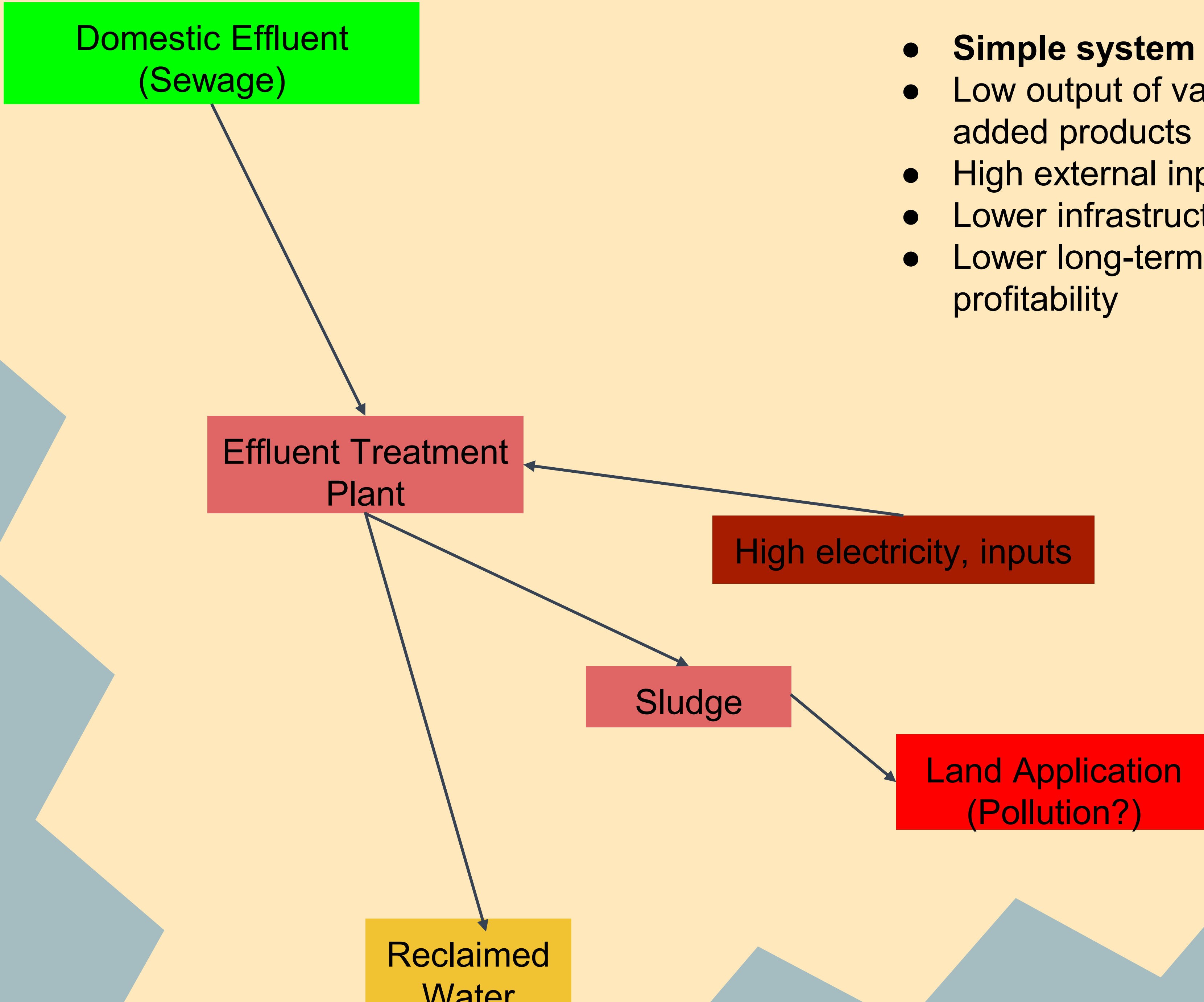
1. Food waste --> Landfill with other solid waste --> Pollution and GHG emissions, breeding of vectors and diseases, loss of value of recyclables, contamination of groundwater --> **net loss.**
2. Food waste --> composting --> sell compost --> **earn profits.**
3. Food waste --> Cow --> milk and dung
   - Sell milk (or consume) --> **earn profits** (or displace expenses)
   - AND compost the dung
     - --> sell the compost --> **earn profits**
     - OR --> grow vegetables ***on greywater*** --> sell vegetables --> **greater profits**

Amplify the Benefits

For a certain type of organic waste:

- Identify an organism (plant or animal) that consumes it and yields a human-useful product e.g. a cow, goats, egg-laying birds
- Among the alternatives, choose the organism which:
  - is robust and requires minimal care,
  - has a high resource conversion efficiency
  - yields products of high value.
- Explore if an integrated management of solid waste, energy, food, liquid effluent gives any significant advantages.

- **Simple system**
- Low output of value-added products
- High external inputs
- Lower infrastructure
- Lower long-term profitability



Domestic Effluent (Sewage)

Open wetland with ducks

- **Complex system**
- High output of value-added products
- Low external inputs
- Higher infrastructure
- Drastically higher long-term profitability

Plant Biomass (e.g. water hyacinth, algae)

Biogas or Pyrolyis Plant

Reclaimed Water

Eggs

Energy

http://www.indiangreenservice.com/resources.html

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Plastic Waste Usage Priorities

Plastic waste should be used in the following order of priority. Only if unfit for one category should it be used for the next:

1. Reuse the plastics (materials and products) for a lower value application. **Caution: Do not reuse plastics for food or drinking water applications due to toxicity hazard.**
2. Segregate based on type and recycle to make lower quality products.
3. Poor quality plastic waste can be converted to fuel (gas or liquid) by pyrolysis techniques.

Dry Biomass Waste Usage Priorities

Agricultural biomass residue or garden waste biomass should be used in the following order of priority. Only if unfit for one category or present in excess or requirements should it be used for the next:

1. Feed and bedding for milch animals.
2. Ground mulch (shredded or unshredded as convenient) for agriculture...cattle bedding is ideal.
3. Feed for biogas plant...use effluent slurry for food farming.
4. A small fraction of dry biomass can be converted to fuel (gas or liquid) by pyrolysis techniques.

Human Waste Usage Priorities

Human waste should be disposed of and used in the following order of priority. Only if the first is not feasible should the subsequent ways be adopted:

1. Use urine separation, dry composting toilets. Apply urine directly to trees and to herbaceous crops only if using drip irrigation. Use compost after due ageing (eliminate pathogens) to fertilize tree crops. Avoid applying to herbaceous and root crops.
2. Send mixed human waste from flush toilets to wetlands or photobioreactors. Harvest biomass and convert to energy by pyrolysis or biomethanation. Residual biochar or waste sludge can be used for gardening.

Human Waste Usage Priorities

3. Send mixed human waste from flush toilets to a biogas plant. Waste sludge can be used for gardening.
4. Send mixed human waste directly into compost pit.

Check WHO Guidelines for the safe use of wastewater, excreta and greywater

Animal Waste Usage Priority

Animal waste should be disposed of and used in the following order of priority. Only if the first is not feasible should the subsequent ways be adopted:

1. Separate urine (esp. cow urine) and use for fertigation directly or after preparing liquid biofertilizers like Panchagavya via drip irrigation.
2. Send solid waste to biogas plants and recover energy (gas) as well the spent slurry. The slurry can be used as fertilizer preferably after vermicomposting or ageing.

Organic Waste Usage Priorities

Kitchen and food waste should be used in the following order of priority. Only if unfit for one category should it be used for the next:

1. Feed for milch animals (collect the milk and send dung to biogas plant)
2. Feed for egglaying birds (recover the eggs and send the excreta to the biogas plant)
3. Feed for Biogas plant (recover the gas and use the waste slurry for agriculture)
4. Direct Composting (use the compost for agriculture)
5. Feed for pyrolyzer/gasifier (recover the gas and use the biochar for agriculture)

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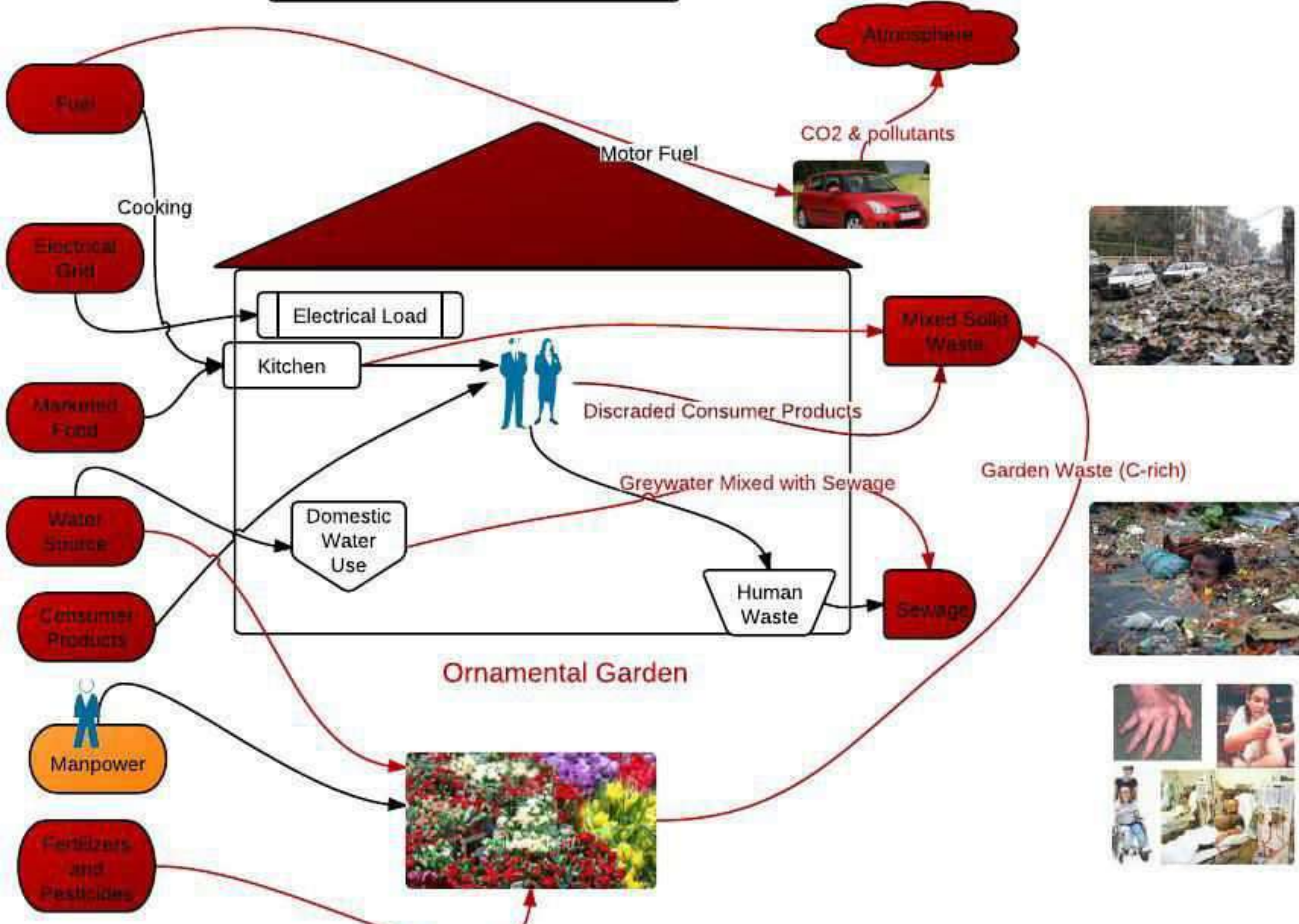
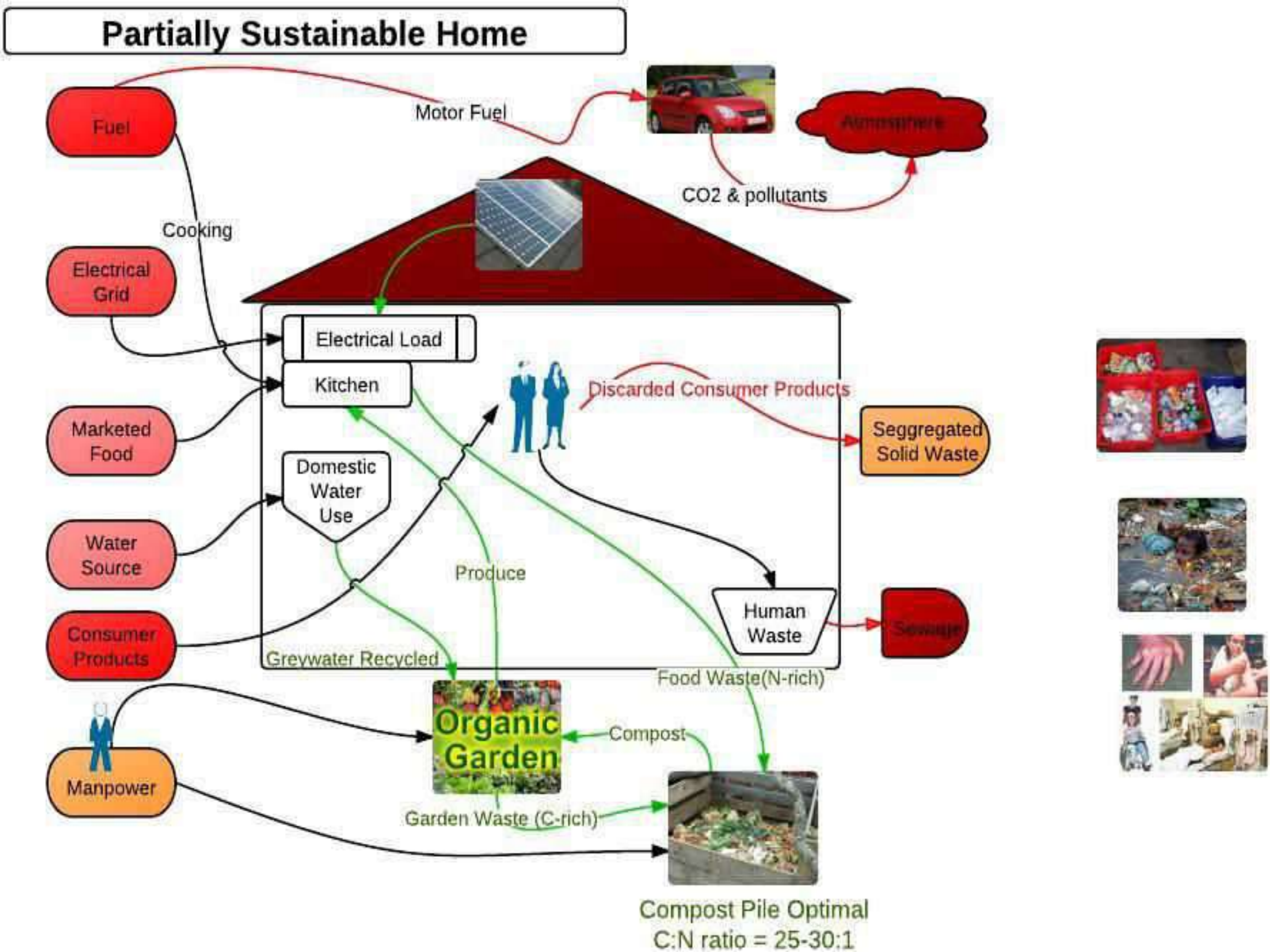
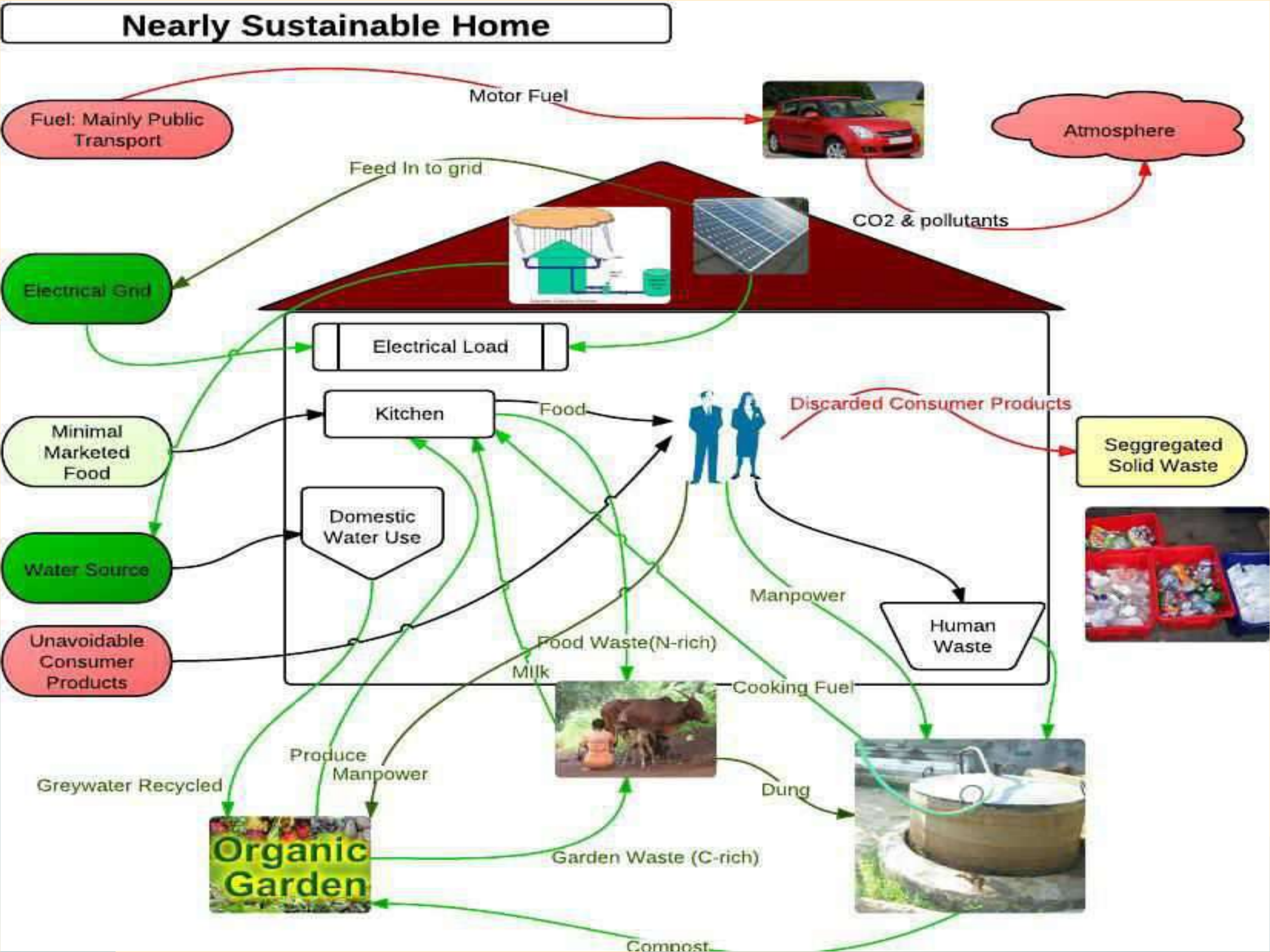
Conventional Home





Partially Sustainable Home
Fuel
Motor Fuel
Atmosphere
CO2 & pollutants
Cooking
Electrical Grid
Electrical Load
Kitchen
Marketed Food
Discarded Consumer Products
Seggregated Solid Waste
Domestic Water Use
Water Source
Produce
Human Waste
Sewage
Consumer Products
Greywater Recycled
Food Waste(N-rich)
Organic Garden
Compost
Manpower
Garden Waste (C-rich)
Compost Pile Optimal
C:N ratio = 25-30:1


Nearly Sustainable Home
Fuel: Mainly Public Transport
Motor Fuel
Atmosphere
Feed In to grid
CO2 & pollutants
Electrical Grid
Electrical Load
Minimal Marketed Food
Kitchen
Food
Discarded Consumer Products
Seggregated Solid Waste
Domestic Water Use
Water Source
Manpower
Human Waste
Unavoidable Consumer Products
Food Waste(N-rich)
Milk
Cooking Fuel
Produce
Manpower
Greywater Recycled
Dung
Organic Garden
Garden Waste (C-rich)
Compost

LINKS

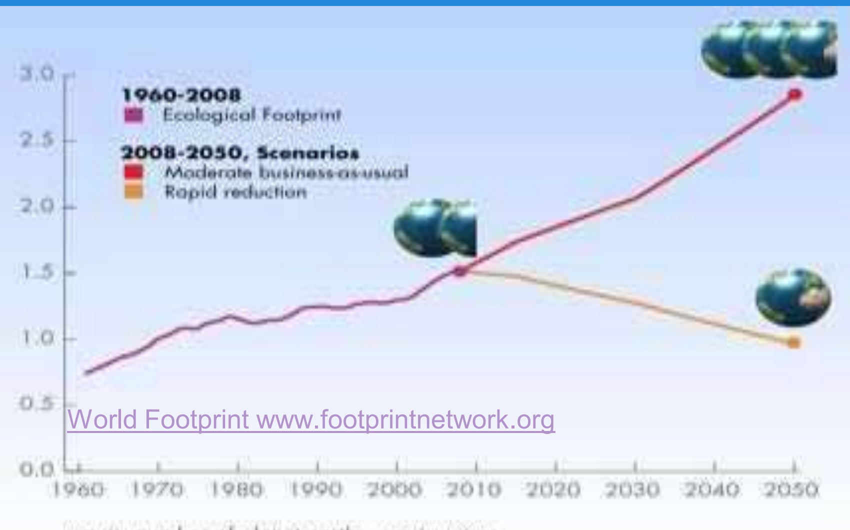
Paradigm Environmental Strategies (P) Ltd.: Implementing sustainable and eco-friendly development projects including integrated waste management

July 2011

Sustainability Philosophy

ENV200 Environmental Studies

Problem of Unsustainability



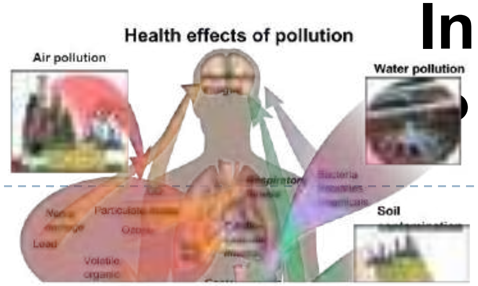
World Footprint www.footprintnetwork.org

Environment in crisis:

- Earth-threatening environmental problems
- Ecological footprint exceeding Earth's biocapacity.

Society in crisis:

- War, terrorism
- Poverty, hunger



Individuals in crisis:

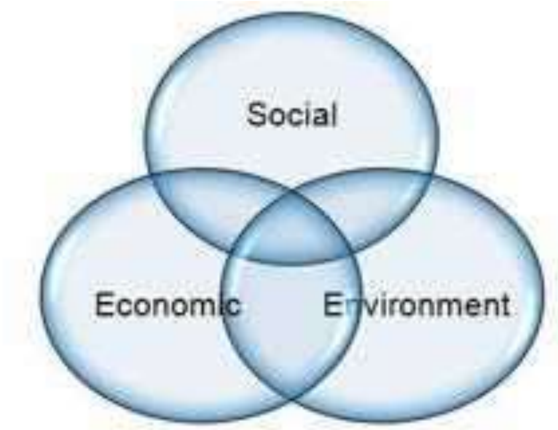
- Health and psychological problems

We have reached a point where, development, which aims at the survival and prosperity of humanity, ironically threatens our very existence today.

We need a paradigm shift in our approach towards development...Sustainable Development.

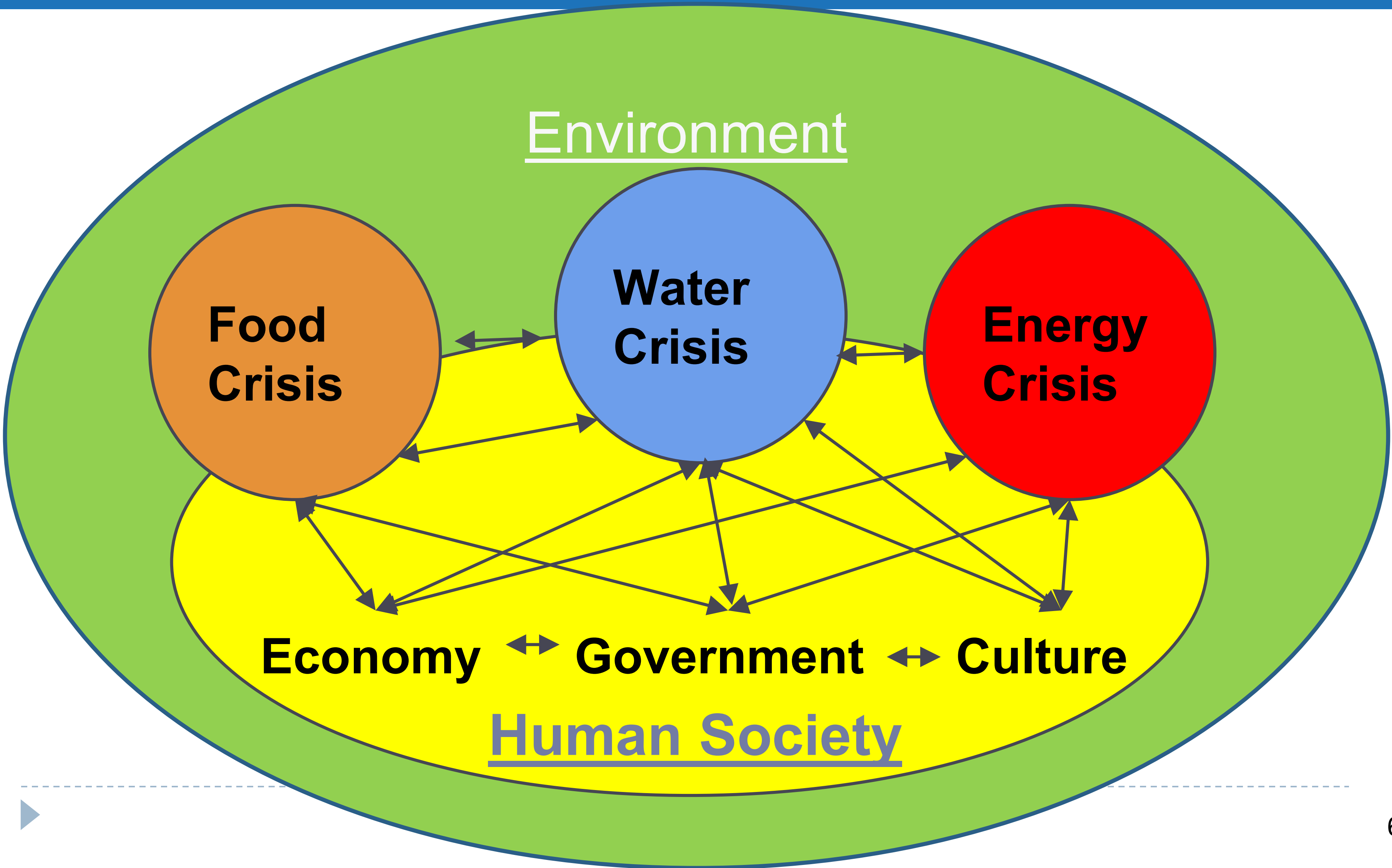
Sustainable Development (SD)

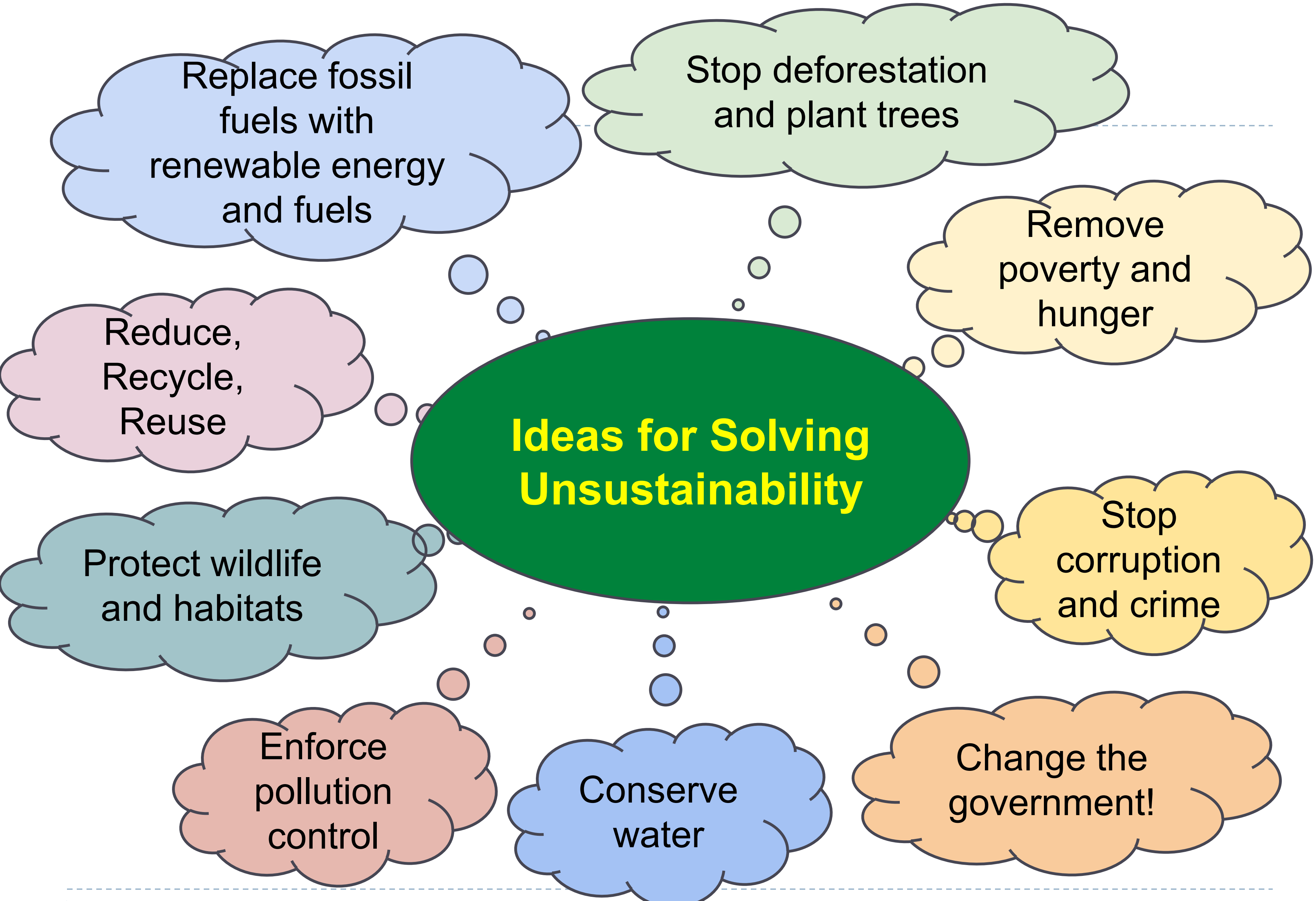
- SD is the **economic development** to meet **human needs** while preserving the **environment.**
- Meet needs into the indefinite future.
- Present economic growth is unsustainable since it leads to social inequities and environmental damage.
- Economy, Society, Environment: 3 interdependent and mutually reinforcing pillars of SD.



How can we move towards sustainability?

Interactions in Socio-Environmental Problems





Ideas for Solving Unsustainability
Replace fossil fuels with renewable energy and fuels
Stop deforestation and plant trees
Remove poverty and hunger
Reduce, Recycle, Reuse
Stop corruption and crime
Protect wildlife and habitats
Enforce pollution control
Conserve water
Change the government!

Superficial Solutions Cannot Bring Sustainability

- Stop Using Plastic Carry Bags
- Tune-Up Car Engine to Reduce Emissions
- Plant A Few Plants in Your Balcony
- Separate Solid Waste in Your Home

Superficial Solutions Cannot Bring Sustainability

Superficial Solutions Cannot Bring Sustainability

Substantial and Comprehensive Steps and Needed

UN’s Sustainable Development Goals

https://en.wikipedia.org/wiki/Sustainable_Development_Goals

Integrated Approach: Coordination is a Must

Government

Sustainability-Based Governance and Policies

↕

Regulatory Agencies

Strict and Impartial Regulation

↕

Industry

Green Businesses & Technologies

↕

NGOs, Consumers, Citizens

Educated, Socio-Environmentally Responsible Citizens

Where do you find all these (or at least many of these) requirements of sustainability implemented?

Nowhere yet in a big way...unfortunately. But...

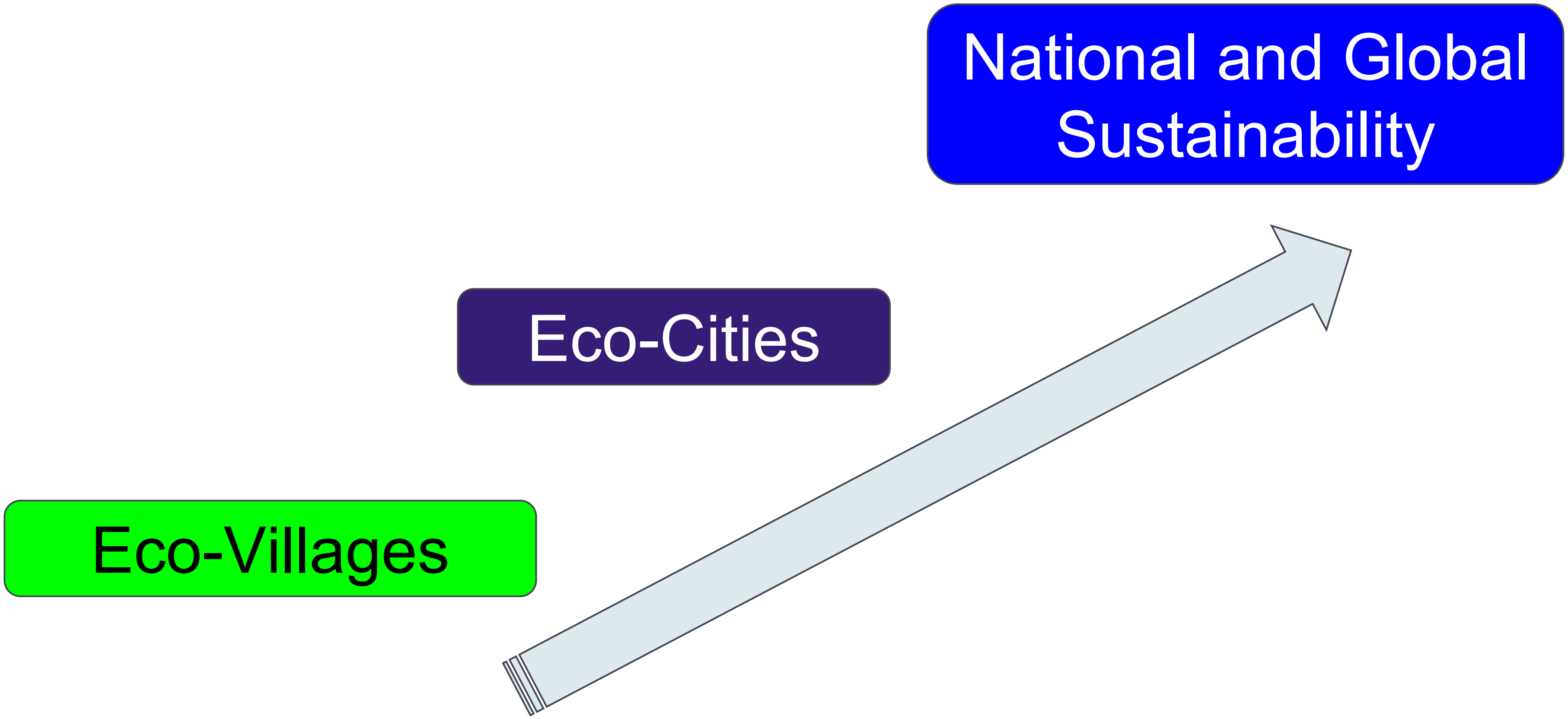
Sustainable Communities, Ecovillages, Eco-Municipalities

www.permaculture.lv

http://ecovillagebook.org/wp/wp-content/uploads/slide8.jpg

Numerous small experiments worldwide prove the practical feasibility of living sustainably on Earth.

Need to Scale Up



A lot of individual effort, collective effort and political will will be required.

Insufficiency of Even an Integrated Solution

But let's assume that we somehow managed to design and build a sustainable world.

After drastic changes to our:

- resource management methods
- industrial processes
- business and economics
- governance, policy and regulation.

Can we be sure that such 'sustainability' will last?

Or would it revert to the state of unsustainability?

Need for a Permanent Solution

- In ancient times, most people lived in villages.
- These villages were largely self-sufficient and sustainable, even if technologically primitive.
- The drive for more comforts and amenities ended up disrupting the cyclical (sustainable) resource use.
- People used technology to fulfill their immediate interests at the expense of the environment.
- Collective result → unsustainability.

https://upload.wikimedia.org/wikipedia/commons/5/5e/Old_simpel_primitive_houses_in_Gambia_of_a_village.jpg

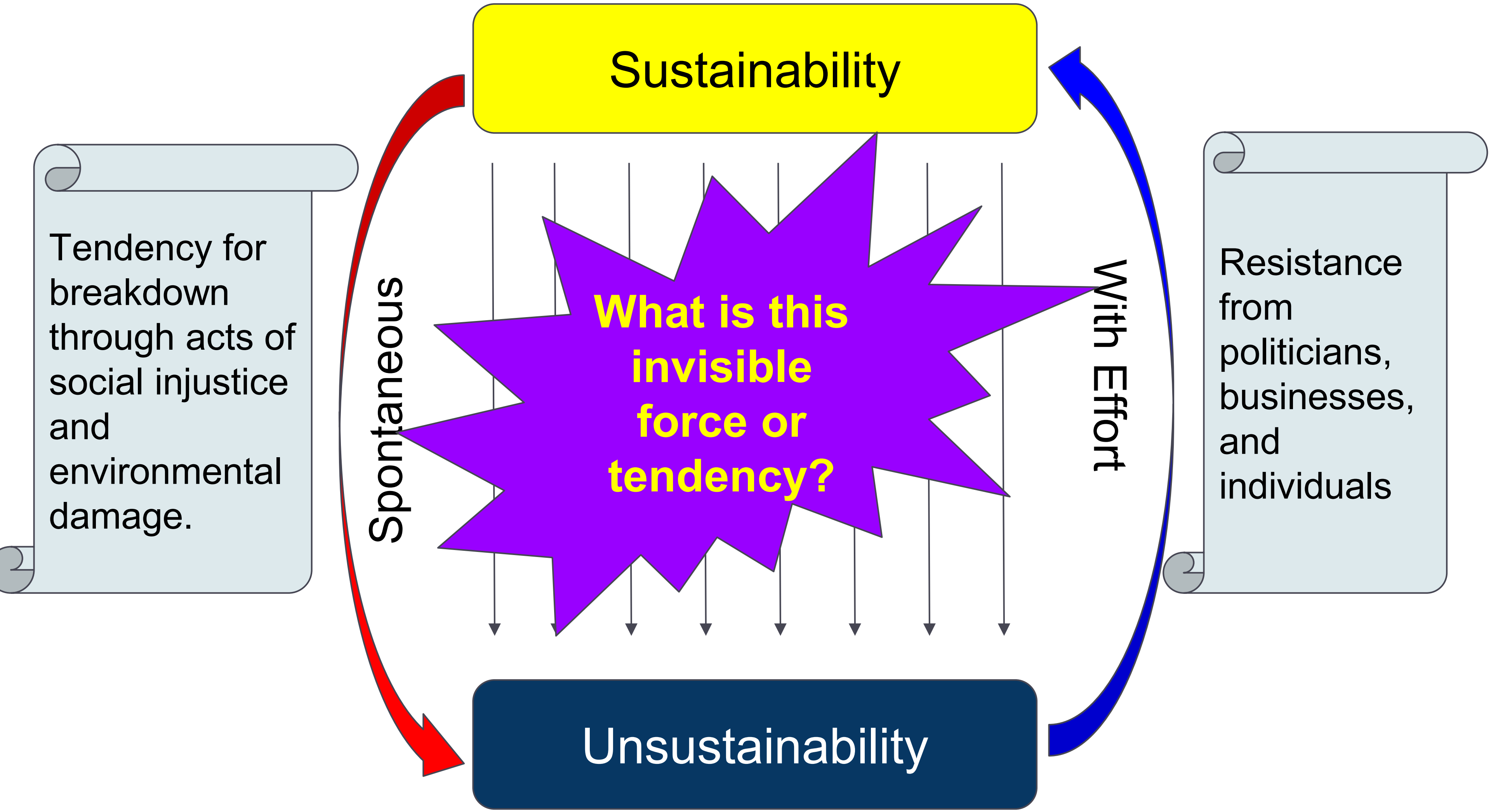
Need for a Permanent Solution

- So even if we somehow achieve ‘sustainable development’ in this generation, people will cause it degrade in a couple of generations.
- So, such ‘sustainability’ will be temporary at best.
- But we need a permanent solution.
- Temporary sustainability is not sustainability at all!

https://www.occupycorporatism.com/wp-content/uploads/2013/04/futuristic-eco-city-center1.jpg

http://www.yeniisfikirleri.net/wp-content/uploads/2015/05/eko-koy-620x350.jpg

Cause of Unsustainability: The Missing Link



So what are we missing???

Actually, we are missing the most important thing!

We have not done--a proper diagnosis--a root cause analysis.

How did we assume that sustainability is even possible without understanding what fundamentally causes unsustainability?

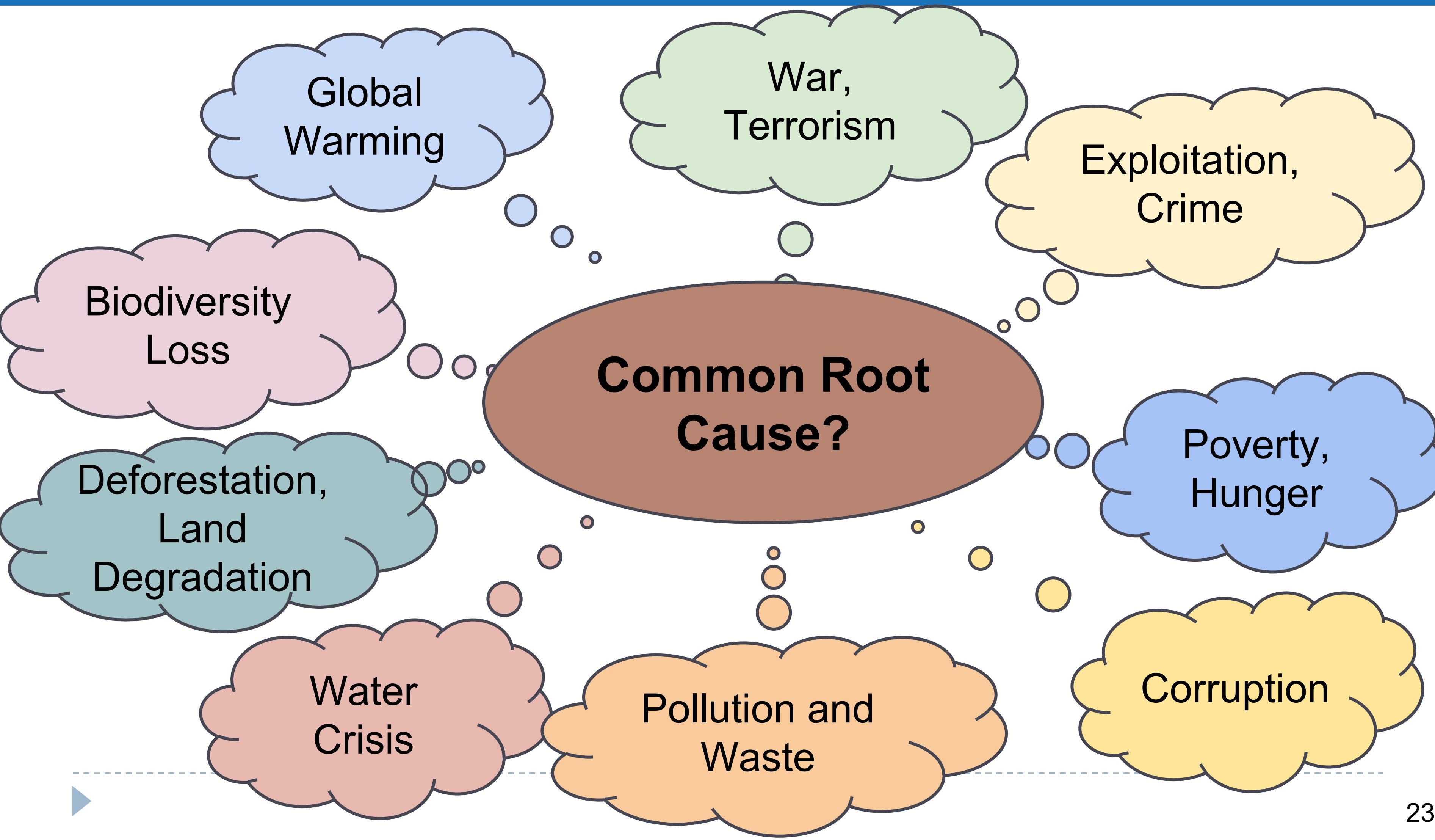
A deep enquiry into the root cause of unsustainability is most essential....

Multiple Symptoms Caused by a Single Common Disease

Two approaches must be pursued simultaneously:

- **Controlling the external symptoms (temporary solution).**
- **Diagnosis and treatment of the disease (permanent solution).**

Common Root Cause for Social and Environmental Problems?



So, let's start searching for the **root cause** of

Unsustainability...

Did Technology Cause Unsustainability?

- **Many of the environmental problems appear to be caused by modern technologies**
  - E.g. Global warming is caused by the discovery and use of fossil fuels, for transportation and power.
- **Then is scientific development the culprit?**
- **No. Science or knowledge is value-neutral (neither good nor bad) and hence blameless.**
- **Only upon its application, i.e. turning it into technology does it become value-loaded (good/bad).**
- **The actual blame or credit goes to the decision-maker (human), who decides to use any knowledge for a certain application.**
  - The knowledge of explosive chemical reactions can be used by one person for mining rocks for house construction (good application) or by another person, to make a bomb (bad application).

Did Technology Cause Unsustainability?

- **Why does a human being decide to use knowledge (science) for a certain purpose (good or bad)?**
- **The *unsustainability of modern development is the result of some deficiency in the* decision-makers.**
- **Even when they were field-experts, they failed at being good and moral human beings.**
- **If these technically competent decision-makers also had high moral integrity, they could have prevented unsustainability by using knowledge for socio-environmentally appropriate technology development.**

Humanity, has thus achieved great success at science and technology but it has failed at morality.

Back to Outline

Unsustainability: A Moral Failure

For instance take fossil fuel burning and global warming:

- Knowledge/Science (value-neutral):
  - Combustion of a carbonaceous material in air leads to the release of heat accompanied by a volumetric expansion.
  - Large reserves of buried carbonaceous material are available.
- Application (value-loaded):
  - the petroleum drilling entrepreneur decides to drill an oil well and sell the oil for profit to a refinery owner; both neglect environmental or social impacts.
  - Another entrepreneur sets up a plant to make cars; no pollution or global warming effects are considered.

Unsustainability: A Moral Failure

- Application (value-loaded): …continued
  - Rich people buy several cars; even inefficient gas-guzzlers for luxury and thrill; with total disregard to the environment or society.
  - The field experts (engineers, managers, consultants, etc.) and other allied businessmen accept salaries, fees or profits without questioning the company's intentions or considering the socio-environmental impacts.
- The Result: Unsustainability → global warming, pollution and associated human deaths and illness, environmental degradation.
- At each step, human beings took decisions based on selfish interest alone; disregarded the impacts on society and environment—Tragedy of the Commons.

A series of moral failures of human beings at each level.

Back to Outline

Let’s try to understand the relation between our consumption of resources and sustainability.

Consumption and Unsustainability

- Most environmental problems are linked to consumption of material and energy resources.
- Most social problems are related to control over resources (wealth and power).
- Thus, the cause of unsustainability is related to

CONSUMPTION.

But we need to consume in order to survive.

What's wrong with it?

True. There's nothing wrong with consumption for the sake of survival...but when we consume, is our focus on survival or something else?

Motivation for Consumption

- Satisfying our physical needs is consumption.
- It is the means to survival.
- And how do we know what to consume, when to consume and how much to consume?
- Nature has given us the pleasure and insecurity/pain mechanism.
- They are Nature’s reward & deterrent mechanism.
- They motivate action (consumption) and ensure the individual’s survival.
- They are like an indicator telling us when and how much to act.
- So in effect, we act and consume so that we feel secure or pleasure (and to minimize the feelings of insecurity or pain).

- Further, since our security and pleasure is tied to that of our family (by instinct and circumstances), we work (act) even for the sake of their consumption.
- But mental factors (thoughts) can greatly influence this ‘indicator’ mechanism.
- So it is not a reliable indicator of what we need for survival, esp. after securing physical survival.
- In other words, whatever I want or whatever gives pleasure, need not be necessary for my survival or long term benefit.

- So actually, any call for action by this mechanism, must be resolved not merely by action (leading to consumption) but also by appropriate thinking (knowledge).
- I.e. We must think before we act upon our impulses.
- But alas we often don’t!

Needs vs. Wants

- Thus, consumption is necessary for survival.
- But all that we consume is not required for our survival.
- Being tuned to the pleasure-pain mechanism, we normally consume to ***maximize our feelings of security and pleasure.***
- We don't usually check if that consumption is really necessary for survival (of oneself/family).
- **Our focus becomes security and pleasure; not survival.**

Unethical Consumption Causes Unsustainability

- Hence, there is a tendency towards unethical consumption:
  - Consuming what rightfully belongs to another (stealing, corruption, etc.).
  - Consuming excessively even when others face scarcity or the adverse impacts of your consumption (greed).
- This unethical consumption leads to unsustainability.
- In general, we can say that unethical behavior (immorality) leads to unsustainability.

Why do we behave unethically?

Unethical behavior (and consequently unsustainability) is the result of <u>two misconceptions</u> regarding consumption.

What Causes Selfish and Unethical Behavior?

Knowledge → Action

Right Knowledge
Smoking is dangerous
→
Right Action
Avoid smoking

Wrong Knowledge
Smoking is a sign of manliness
→
Wrong Action
Smoking to impress

- A value is nothing but strong conviction (reinforced knowledge) that motivates a certain pattern of behavior.

Why do we behave unethically?

If the behavior is unethical, it indicates wrong values, which are produced by wrong understanding (misconceptions).

Unethical behavior is the result of

<u>TWO MATERIALISTIC MISCONCEPTIONS</u>

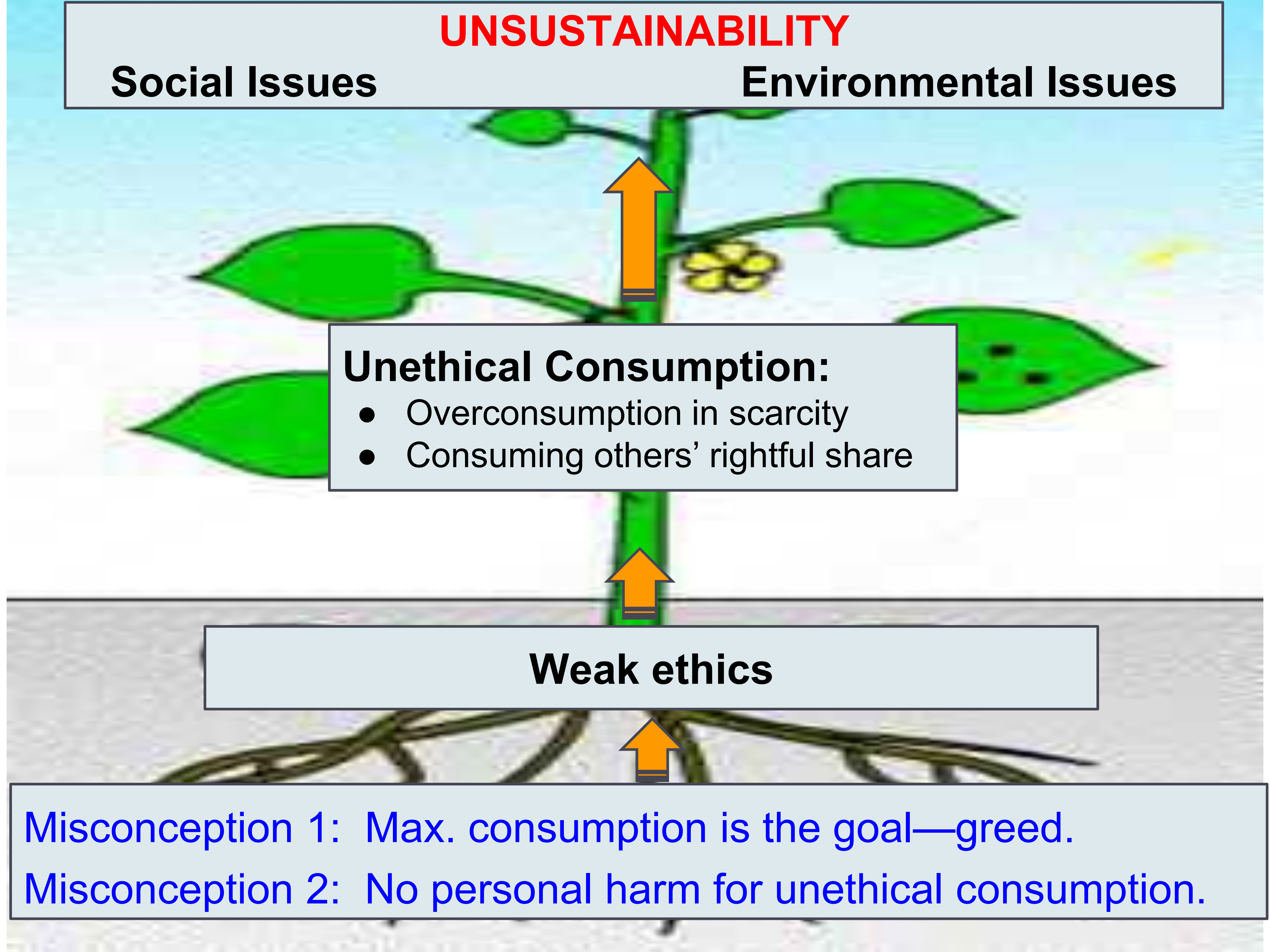
Root Causes of Unsustainability

- **Misconception 1: More consumption is always and unconditionally better. (i.e. maximum consumption is practically the goal of our life.)**
  - Actually, more is better only as long as our physical needs have not been met (survival). *Excess could be useless or even harmful.*
  - If the consumptive survival instinct refuses to shut off even after meeting one's needs, one consumes/ accumulates in excess (overconsumption). It becomes ***selfish greed***.
  - Beyond the physical needs, consumption is done due to an obsession for safeguarding security, (accumulation/ hoarding) or for thrill (pleasure-seeking).
  - Most people are unclear about any goal of life higher than survival. So, after the physical needs are met, there is a goal-crisis. Most of us lack the ability to identify a goal significantly different from mere survival.
  - Consumption, which is usually the means to survival, then takes over as the **practical goal** of our life...

Root Causes of Unsustainability

- **Misconception 2: We believe that unethical consumption has no <u>personal</u> adverse consequences.**
  - **Unethical consumption,** i.e. consuming others' rightful share (stealing, corruption, etc.) and overconsumption (greed) can be minimized only where the law is strict, fast-acting, and comprehensive enough.
  - However, such societies can get suffocatingly restrictive. And since no law or system can be perfect, individuals still find loopholes. Such a system itself is unsustainable!
  - In more liberal societies, where individuals get more freedom to allow culture and creativity to flourish, unethical consumption is also rampant, since the law is less restrictive.
  - People think that unethical consumption is fine as long as they can manage to not get caught.
  - We are *unable to appreciate and respond to a long term general adverse consequence. We respond only to personal and immediate consequences*. This is the cause of the Tragedy of the Commons.

Back to Outline



UNSUSTAINABILITY
Social Issues
Environmental Issues
Unethical Consumption:
● Overconsumption in scarcity
● Consuming others' rightful share
Weak ethics
Misconception 1: Max. consumption is the goal—greed.
Misconception 2: No personal harm for unethical consumption.

That seems easy!

Since, unsustainability is caused by unethical (immoral) behavior, the solution obviously is moral instruction….

We must simply instruct the public to be moral. Right?

Can moral instruction lead to morality and sustainability?

Merely instructing people to be moral is not sufficient.

When a person's *practical goal* in life is more and more consumption, why would he give up or even reduce it?

- ***For the sake of others?*** Or for the sake of green plants, cuddly animals and colorful butterflies?....ridiculously unlikely!! What does he gain in return for saving them?
- ***For fear of the law?***...Only if he is not smart enough to escape from the law!
- ***For the sake of his own honor?***...Money, self-benefit and self-gratification is more important than honor to most people.
- ***For the sake of respect in society?***...As long as he can keep his unethical behavior secret, he'll still be respected.

Moral instruction is most likely to create hypocrites who are eager to instruct and even force morality on others while they carry on with their immoral ways in secret.

So, we cannot stop unethical behavior (and unsustainability) as long as the two misconceptions exist in our minds.

How can we restore our morality and establish sustainability?

- Sustainability can be achieved only if we can remove the two basic misconceptions that cause immoral behavior (unethical consumption).
- i.e. The person must understand and be fully convinced that:
  - **Consumption is only a means; not a goal.** Beyond a point, its marginal utility reduces and it ceases to be self-benefitting**.** It could even harm oneself. *The goal of human life is different and must be investigated in one's limited lifetime.*
  - **Immoral/unethical actions have personal adverse consequences, even beyond the law of the land.** I.e. even if you can escape from the law now, you will have to personally face punishment/penalty in some other way.

Such a person will be naturally self-controlled and ethical, even in the absence of an external law and order system.

What Causes Selfish and Unethical Behavior?

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- A value is nothing but strong conviction (reinforced knowledge) that motivates a certain pattern of behavior.

How can we restore our morality and establish sustainability?

- If morality can be restored by "**Removing misconceptions**" and "**making a person understand**"…
- It clearly points to some field of knowledge.
- Which is that field of knowledge that discusses about:
  - The **human goal** (rejecting consumption as the goal) and
  - the **consequences of one's actions**, even beyond the law of the land?
- It is SPIRITUAL KNOWLEDGE.
- **Spiritual knowledge is in fact the foundation of morality.**
- Without spiritual knowledge, it is extremely difficult to convince a person why he should be moral.

Spirituality is the Foundation of Morality and the Permanent Solution for Sustainability

- Spiritual knowledge explains the goal of human life in detail.
  - **All philosophies unanimously reject consumption as the goal**. It is accepted only as a means to survival and achieving basic comforts, with a clear explanation of the adverse effects of overconsumption.
  - The goal is variously defined in different philosophies, as moksha, sayujjyam, kaivalyam, God-realization, nirvana, etc.
- Spiritual knowledge also discusses about the personal consequences of one's actions (moral and immoral):
  - Most religions have a concept of the **Omniscient God** watching every action of ours.
  - Indian philosophy, describes the **Law of Karma**, which ensures that a person gets proportionate fruits for all his actions (good or bad).
  - Most religions also have similar concepts such as **heaven and hell, judgment day** etc., whereby each person has to face the consequences of his actions.

Spiritual Knowledge the Fundamental Solution

Materialistic Misconceptions	**Virtuous Concepts From Spiritual Knowledge**
More is Better Getting more is the goal	Consumption is the means Human goal is spiritual
Consequences Can Be Avoided I can violate ethics fearlessly	Consequences are Unavoidable Must behave ethically

Wait a minute!

Who cares about spirituality?

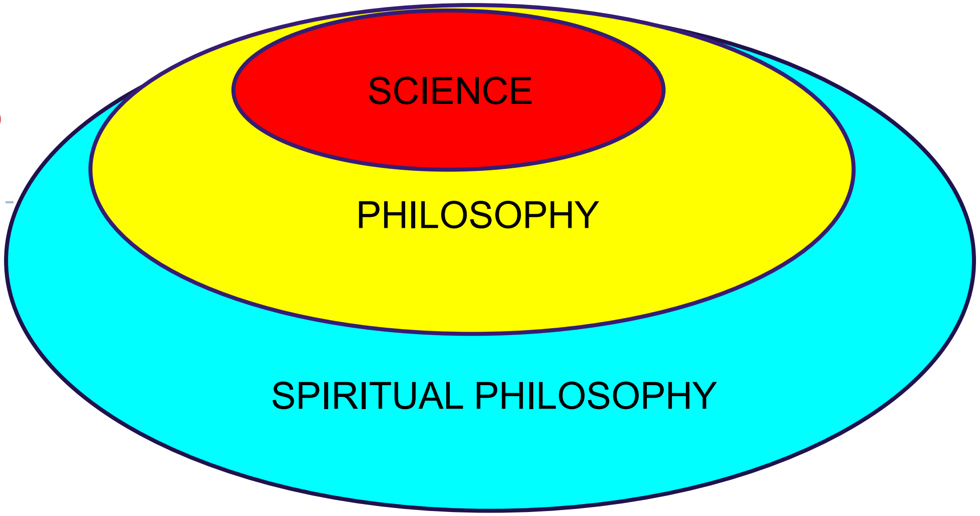
In the modern age, no one wants to be carried away by a bunch of blind faith!

Isn't spirituality the same as blind faith?

- **No, spiritual knowledge is rational and it requires repeated analysis from different perspectives. It is not blind faith.**
- Moreover, it deals with many other concepts that have immense benefits for the person and society.
- **Successful analysis and complete understanding of the concepts involved, gives the individual a strong conviction that motivates right action.**
- Moral behavior is thus an effortless and automatic consequence of fully understood spiritual knowledge.
- **Morality that is based is based on clear spiritual knowledge is both firm and permanent.**

Back to Outline

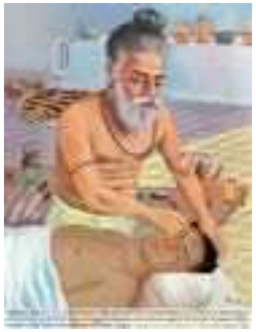
What is Spirituality?



- Enquiry of Nature (Universe) is the common thread tying Science and Philosophy (Spiritual Knowledge):
- Spirituality includes science—superset of science.
  - Philosophy is the mother of science and spiritual philosophy is the mother of philosophy.
  - In ancient India, science (tarka) was an essential prerequisite for studying philosophy.
  - A number of ancient and modern times, philosophers were also scientists. e.g. Socrates, Plato, Aristotle, Heisenberg, Einstein, Gautama, Bhaskara.

Spiritual Masters Contributed to Science

- A number of spiritual scientists (philosophers, rishis), also made great scientific contributions in a number of fields.



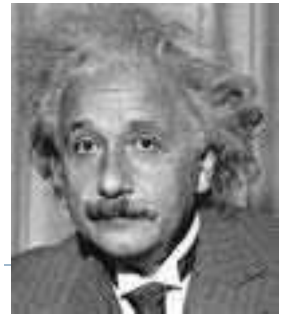
Modern Scientists and Thinkers Who Were Deeply Spiritual

- A number of modern scientists and thinkers were themselves very spiritual and have even showered glowing praises for scriptures like The Gita and the Upanishads, Ramayana, and the Vedanta philosophy in general.

Arthur Schopenhauer

Erwin Schroedinger

Albert Einstein



Robert Oppenheimer

Ralph Waldo Emerson

Even if that is true, we still don't want anything to do with spirituality or religion because it leads to fanaticism, terrorism and wars...

Does spirituality lead to fanaticism?

- In fact, fanaticism is caused by misinterpretations of spiritual concepts, which are forced upon the public as religious ***dogma*** (beliefs that are accepted without evidence or reason).
- Spirituality is the discovery of the Truth.
- Dogma and fanaticism are perpetuated by selfish people who do not want to accept the Truth that is inconvenient to their selfish interests.

- Spiritual knowledge proceeds by eliminating errors, misconceptions and misinterpretations.

- **Spirituality provides clarity and peace.**

OK, spirituality might be a rational truth-seeking process, but don’t all religions demand blind faith?

What’s the connection between religion and spirituality anyway?

What is the Difference Between Spirituality and Religion?

- Spirituality: Universal knowledge.
  - Common philosophical foundation of all religions.
  - Rational analysis...explains the 'why' behind religious practices/traditions.
- Religion: bringing that knowledge to practice in our lives.
  - Core universal practical path of:
    - **pursuing the spiritual goal &**
    - **peaceful coexistence with other people** (ethics)
- Culture:
  - External customs and social behavior.
  - It differs from place to place.
  - It is often influenced by the region's history, geography, climate, and other conditions.

World Religions: Blends of Spirituality, Religion and Culture

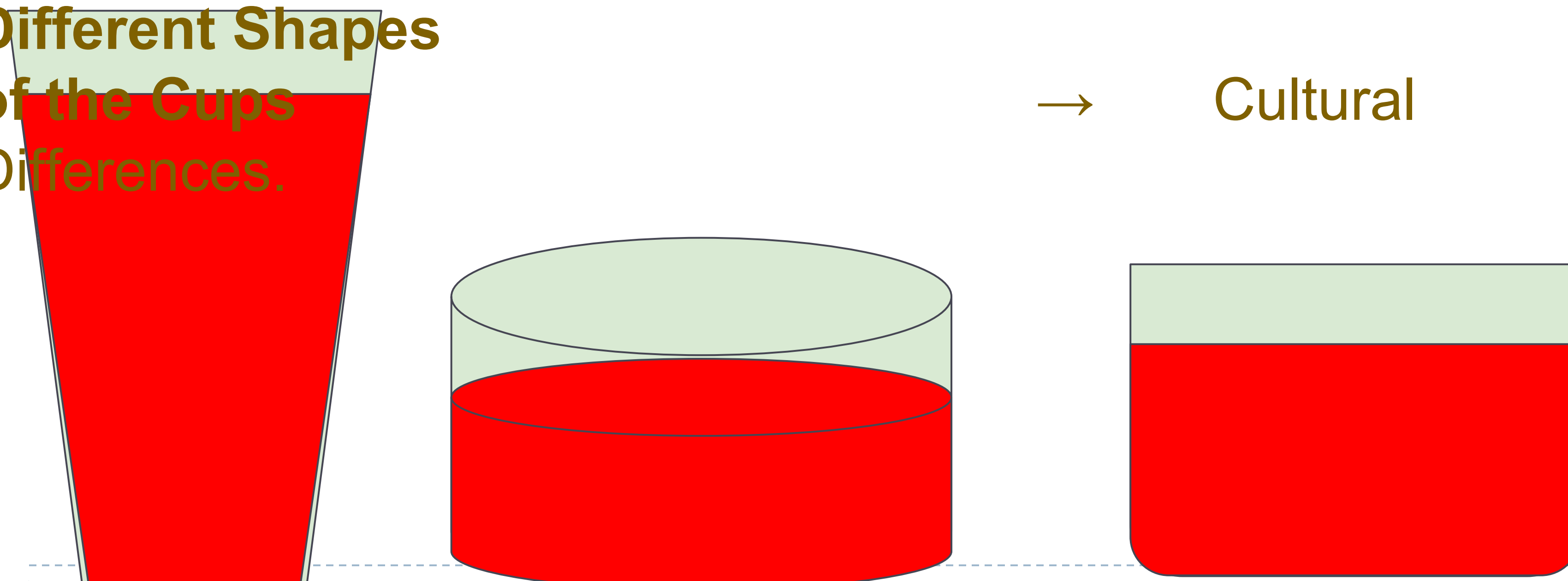
Spirituality (Theory)	Foundation of universal philosophy (spiritual knowledge).
Religion (Practice)	(a) **Worship of God** for achieving the spiritual goal. (b) **Maintaining social justice (ethics)**. Initially, the practical part is often followed without understanding. Through spiritual knowledge the reasons are discovered.
Culture (Style)	Different presentation of common content in each religion. To suit the pre-existing customs and the mentality of the people. Symbols & rituals are teaching tools that help in the assimilation of spiritual knowledge and guide the practice.

World Religions: Same Drink in Different Cups

Common Drink → Universal Spiritual Knowledge.

Common Cup → Universal Religion.

Different Shapes of the Cups → Cultural Differences.



Analogies for Relation Between Spirituality & Religion

	Components of World Religions	Analogy: School Education System
1.	Spiritual Knowledge	Common universal curriculum for all schools.
2.	Religion	Common practical steps in learning: (a) Attending classes, completing assignments, and passing examinations. (b) Peaceful co-existence with other students
3.	Culture	Different schools with different mediums of instruction (language), uniforms, organizational rules and regulations as per people's mentality and local conditions.

Spirituality is to Religion as Science is to Technology

- Both science and spirituality are theoretical and hence **positive** (descriptive/factual).
  - Science and spirituality only explain facts.
  - They do not prescribe or force any particular action.
  - E.g. 1. the scientist explains that petroleum is highly combustible and can burn violently.
  - E.g. 2. "The results of the good/bad actions of each person certainly come back to the person. "
- But both technology and religion are practical and hence **prescriptive/normative.**
  - They prescribe a particular action, since they are both application-oriented.
  - E.g. 1. The engineer prohibits his workers from lighting a fire anywhere near petrol tanks.
  - E.g. 2. "Thou shalt not kill."

Let’s try to further clarify the relation between spirituality and religion by taking another analogy...

Analogy: Chemistry and Lab Instructions

- The scientist understands the properties of chemicals in a chemistry lab and their dangers to humans.

- But most students do not understand them.

- So, to make it simple for the students and ensure their safety, laboratory safety rules are given in the form of dos and don'ts.
- It is essential to follow the dos and don'ts in the chemistry lab whether students understand the reason behind them or not.

The relation between:

the deeper concepts in chemistry and

the laboratory dos and don’ts

is same as the relation between:

spirituality

and

religion...

Spirituality & Religion

- The sages who had a deep understanding of spiritual principles, realized the relation between our actions and their consequences

- But common people could not understand it.

- To make things easier for them and to ensure societal peace, the sages gave them simple moral codes (dos and don'ts) to be followed whether or not people understand the reason behind them.—**Religion**

Spirituality is the Basis of Morality

- Those who wish to discover the reason (deeper principles) behind the dos and don’ts are welcome to study spiritual knowledge.
- That is why spirituality is the basis of morality.
- Without spiritual knowledge, it is extremely difficult to convince a person why he should be moral.

If spirituality is actually that good, then why are so many so-called ‘spiritual’ people not following spiritual principles?

They are getting involved in corruption, scandals and crime…

Why can’t they practice what they preach? They are hypocrites!

Are Spiritual Followers Hypocrites?

- **Hypocrisy** is a false show of a certain attitude or behavior in public, which one does not really possess.
- **It is a human trait that applies to persons in all fields; not just spirituality.**
- It is argued that spiritual followers are hypocrites and do not practice what they preach. .
- **Some individuals have a greater tendency towards hypocrisy than others.**
- An aspirant on the spiritual path has, by definition, not reached the goal. So, a gap between his thinking and practice is inevitable.
- For example, an engineering student is not an expert at engineering yet; but he will eventually become.
- **Some aspirants claim to be greater or better than they actually are, to gain respect or benefits from others.**

Are Spiritual Followers Hypocrites?

- Thus, the inevitable gap between the understanding and practice of spiritual followers, or individual tendencies for hypocrisy, cannot be reasons for rejecting spirituality altogether.
- In fact, hypocrisy results only from an incomplete understanding and assimilation of important spiritual concepts.
- Progressing further to assimilating those concepts will remove the tendency eventually.
- **This only emphasizes the importance of acquiring an accurate and complete understanding of spiritual knowledge, assimilating it fully and practicing it in our lives.**

There are some serious doubts regarding the validity of spiritual knowledge.

How do we know it is true and correct? Some of the claims made by spirituality are impossible to even verify.

So, when it’s reliability itself is doubtful, why bother about it?

Is Spiritual Knowledge Valid and Reliable?

Spiritual knowledge is as valid as science; if not more.

- Both science and spirituality deal with two types of items (to be known):
  - Items/concepts that can be directly perceived by our 5 senses.
  - Items/concepts that cannot be directly perceived.
- Spiritual knowledge discusses about some concepts such as heaven, hell, God, rebirth, etc., which are difficult/impossible to directly verify.
- Science too has concepts that are difficult/impossible to directly verify: e.g. subatomic particles, concepts in theoretical physics, some laws of thermodynamics, and concepts in cosmology.

Is Spiritual Knowledge Valid and Reliable?

Both science and spirituality rely on common means of acquiring knowledge about both types of items and verifying its validity:

- **direct perception**:
  - for items that are perceptible to senses.
- **indirect perception:**
  - For items that are difficult or impossible to perceive, logical theories (sometimes assisted by instruments) can be used.
  - The observations are perceptible.
  - The theory (logic) relates the observations with the imperceptible object in such a way that it does not contradict alternative (indirect) ways of verification.
  - Thus, by making the relevant observation, one can infer even imperceptible facts.

Is Spiritual Knowledge Valid and Reliable?

- Example of indirect perception (through logic) in science.
  - The atoms present in a chemical sample are imperceptible.
  - So to identify elements, we use a combination of an instrument called a spectrometer and logical theory.
  - A visual display of a spectrum can be related to the presence of certain elements through an elaborate theoretical analysis, which is in agreement with other forms of evidence.
  - While this theoretical analysis is too complicated and abstruse for a lay person, it is as good and reliable as direct evidence for experts in that field, who are familiar with that theoretical analysis.
  - A lay person must believe the word of the expert or else study the entire theory and verify for himself.

Is Spiritual Knowledge Valid and Reliable?

- Spiritual knowledge also uses indirect perception in a similar way.
  - Spiritual scholars have their own theories to relate observations in the world to concepts that are not perceptible.
  - For them these theories are extremely reliable and inferences based on them are as good as direct knowledge.
  - But most of us are lay persons to spiritual knowledge and have never studied those spiritual theories.
  - We can either accept the word of the experts in spiritual knowledge or else study the entire theory and verify for ourselves.
  - We are surely in no position to reject of dismiss these theories without analysis.

Is Spiritual Knowledge Valid and Reliable?

- Apart from direct and indirect perception, spirituality uses an additional means: Scripture (Revealed Word).
  - That Entity, from which this world came and by which it is maintained, can certainly make Itself known to us along with a number of other facts that are inherently difficult/impossible to verify.
  - In fact, statements from Scripture are very similar to the postulates of science.
  - A postulate/axiom is something that is considered to be true, which acts as the basis for any reasoning or discussion, and for which no contradiction has been found so far.
  - Spirituality has a immense wealth of such 'postulates' in the form of scriptures.

Identical Means of Getting Knowledge: Science and Spirituality

Means of Knowledge	**Science**	**Spirituality**
Fundamental principles that cannot be proved rigorously, but are never violated and they form the basis of theoretical analysis	Postulates	Scripture
Direct Perception by 5 senses	Yes	Yes
Indirect perception: Perception of observations, linked to imperceptible items through theory (logic) and sometimes through instruments	Yes	Yes

Even if spiritual knowledge is reliable and valid, why waste time on it?

It is not even relevant to us in modern times. Don't we have more important things to do in life, like pursuing our profession?

Is Spirituality Relevant to Me?

- All beings are subject to the same physical and metaphysical laws that govern this creation.
- Animals follow the laws by default since they are programmed by nature and have no free will.
- Humans have the privilege of learning and understanding these laws and living accordingly so that no harm comes to them.
- Being ignorant of the laws or disregarding them does not exempt you from their influence in any way.

Spirituality is most essential for every intelligent and practical person, who is interested in his/her own ultimate benefit.

Is Spirituality Relevant to Me?

- Basic subjects such as mathematics, science and social sciences, are taught to every student in school irrespective of the student's future career inclinations, since that knowledge is considered to be essential for every citizen.
- **The necessity of spiritual knowledge is even more fundamental in that it provides the basic manual for living and leading one's life.**
- Ironically, no subject in modern education teaches and trains you in this art.
- **Yet we do not seem to be bothered by it and continue to lead our lives blindly!**

Is Spirituality Relevant to Me?

- **Leading a life without a goal cannot be modernism:**
  - In the modern world, no project/mission/organization is ever started without a goal.
  - Yet ironically, we have never bothered to find out the goal of our own life!
- **Ignorance about our actions and their results.**
  - Every living being must perform action even to survive.
  - But each action of ours has consequences—some immediate and some delayed.
  - Action-result are governed by some laws, which are essential for us to know.
  - We ceaselessly perform actions throughout our lives in total ignorance of the laws governing actions. Hence, we sometimes even hurt ourselves in the process.

'Modern' life is the climax of blindness!

Spirituality is Most Essential for Me!

- Spirituality deals with human life and hence, is very much relevant to us.

- Spirituality explains :
  - The goal of human life
  - The way to lead our life so that we can avoid important pitfalls and obtain maximum happiness and satisfaction from our lives.

If spiritual knowledge is the most important knowledge, why don't we just study spirituality?

Why should we unnecessarily study science?

Necessity of Science for Spirituality

- Both science and spirituality are the analysis and discovery of the Reality.
- Spirituality is particularly concerned with the Ultimate Reality.
- But a number of errors can creep into this analysis.
- The progress in science has provided invaluable clarity by eliminating many of these errors in the spiritual analysis.
  - e.g. Literal interpretations of **metaphors** in the scriptures, by some spiritual followers led to misunderstandings that “light”, “fire”, “sound” or “awareness” are the Ultimate Reality (God).
  - Modern science has clarified that all these are mere forms of **energy.**

Science and the Ultimate Reality

- The scriptures say that the Ultimate Reality (God), which is the Source of this universe, is:
  - Beyond all forms.
  - Beyond even the ‘formless’ entities like water, energy, space and time.
  - Beyond logic or imagination of the human mind—(completely and permanently unimaginable).

- **Its <u>existence</u> alone can be detected; Its nature remains permanently unimaginable.**
  - It is possible to detect the existence of an entity without knowing its nature.

Science and the Ultimate Reality

- Science indicates the existence of an unimaginable entity or domain:
  - Unimaginability is inherent in the concept of “infinity” such as the “infinite boundaries of space”.
  - The uncertainty principle—which points out that the reality can never be determined by our mind (logic).

- “Not only is the universe stranger than we imagine, it is stranger than we *can imagine*.”—Sir Arthur Eddington (Astrophysicist, Philosopher).

If spiritual knowledge is so important, why are so many people including scientists against it?

Why is spiritual knowledge not included in the curricula of schools?

The Divorce of the Millennium: Education vs. Spiritual Knowledge

- Modern science was born in the West out of the struggle of truth-seeking scientists against religious dogmatic leaders.
- Hence, science is thought to be anti-religion.
- It does not mean that science and God are actually opposed to each other.
- Innumerable scientists of the past and present, many of them world famous, accept the existence of God.
- For fear of conflicts between the dogmatic beliefs of different religions and between religious dogma and science, spirituality has been excluded from our public life.
- It is like giving up cooking for fear of smoke!
- The exclusion of spirituality from public life is dressed up as secularism.

Back to Outline

The Divorce of the Millenium: Education vs. Spiritual Knowledge

- Most tragically, spiritual knowledge has been filtered out of the educational system.
- Generations have passed bearing the misconceptions that:
  - Worldly knowledge alone is adequate.
  - Spirituality is irrelevant to human life.
  - Spirituality is opposed to science.
- The biggest joke is that these conclusions have been made without even a basic understanding about spiritual knowledge!
- In the absence of spiritual knowledge, there is no wonder that the moral integrity of individuals in society is degrading rapidly, leading to the environmental and social crises!

For Spiritual Education: Catch Them Young!

- Imbibing spiritual knowledge, analyzing it thoroughly, and developing a strong moral character, requires a lot of time.
- It can be best accomplished when started from a young age, when character and habits are still forming.
- **So it is imperative to integrate spiritual knowledge with conventional education from a very young age.**
- This alone can produce generations of self-controlled humans with high moral values...in the long run.

The wheels of <u>true spiritual knowledge</u> turn very slowly; but they grind most surely and finely.

Can regular education and spiritual knowledge be integrated?

- Can education and spiritual knowledge be integrated?
- Will this integration lead to a fair society and protection of the environment?
- Certainly! And there is a precedent too!
- Incidentally, modern (western) society is not the first society to be an education-based society.

Sustainability of The Vedic Society

- The ancient Indian (Vedic) culture, was a knowledge-based culture. “Veda” itself means “knowledge”.
  - Education was started at an early age (like today).
  - **But spiritual and worldly knowledge were integrated.**
  - **In the formative years of a child, the education given was predominantly spiritual.**
  - There was great emphasis on complete and deep understanding through analysis and discussion. It was not dogmatic moral instruction.
  - Questions from the student were encouraged and answered at length.
  - Learning was through listening from the Guru, by following the Guru’s example, by observation (of oneself, others and nature), and through performing practical action.

Sustainability of The Vedic Society

  - The focus was on dedicating one's life to far higher goals than mere survival.
  - Dharma (righteous, just or moral behavior) was the ideal for everyone.
  - The greatest Dharma was defined as "Ahimsa" which is not harming any living being (humans, animals & plants).
  - The law of Karma, heaven and hell were explained in detail as a reward and penalty system; rather than as a threat.
- This society produced great stalwarts of impeccable character.
- Of course there were unjust people and criminals, but they were very few (unlike today).

Environmental Protection In Vedic Society

- Environmental protection through deification of Nature.
- Wise ones superimposed divinity on items in Nature to ensure their protection, even when their actual utility could not be understood by ignorant masses.

Integration of Science and Spirituality

The same high standards of moral integrity can be achieved even today if true spiritual knowledge is integrated with worldly education.

This is also the vision of Amma and our University.

AMMA's keynote address at the United Nations.
UNAI-Amrita Conference on Technology for Sustainable Development

I often reflect deeply on the future of the Earth, the preservation of nature, and the disappearing harmony between humanity and nature.

This contemplation has led me to the conviction that **science, technology, and spirituality must unite in order to ensure a sustainable and balanced existence of our world**.

The present age and the world around us demand this transformation.

- AMMA

Renowned scientists of the past viewed the universe and its subtleties with awe and wonderment.

Their research had the inquisitiveness and faith of an innocent child.

In fact, many past and present eminent scientists acknowledged spirituality towards the end of their lives. But, by then it was too late.

Amma prays that the scientific community leading the world today does not make this same mistake.

\- AMMA

Mission

To provide value-based education and mould the character of the younger generation through a **synthesis of science and spirituality**, so that their earnest endeavour to achieve progress and prosperity in life is matched by an ardent desire to extend selfless service society, one complementing the other.

Integration of Spiritual Knowledge in Education Leads to Sustainability

- Spiritual knowledge taught in a rational manner from early childhood, allows the individual to internalize the concepts and develop a firm conviction.
- This enables the individual to become a responsible citizen of the unshakable moral integrity, since his morality is based on the firm foundation of an accurate and complete understanding of spiritual knowledge.
- Any technology or economic development carried out by people of such high moral integrity will automatically be sustainable.
- They will be able to control their consumption with the knowledge that:
  - Consumption is not the goal of life and not even beneficial beyond a point.
  - Unethical consumption is going to cause considerable personal loss to them, even if they can escape the law of the land.

Integration of Spiritual Knowledge in Education Leads to Sustainability

- They will utilize science (knowledge) in such a way that will ensure prosperity of society while minimizing environmental impacts.
  - Morally sound entrepreneurs, engineers, professionals and consumers will ensure that development is sustainable (even if not mandated by law). Of course the law is an essential deterrent for the invariable (but rare) defaulters.
  - They will thus be able to avert the tragedy of the commons and achieve sustainable development.
- Governance, policy, business frameworks and appropriate technology meeting the new requirements of sustainable development will have to evolve.

Unsustainability: Cause and Solution

- Unsustainable development is due to unethical resource consumption and is a failure of human morality; not science.
- Unethical consumption (corruption and overconsumption) is due to two misconceptions:
  - Consumption is the goal
  - Unethical consumption has no personal adverse consequences
- Rational spiritual knowledge, which is the basis of morality can help achieve ethical consumption (and sustainability) effortlessly.
- **Solutions:**
  - **Real and Long Term Solution:** Integration of true spiritual knowledge with regular education alone can lead us to sustainability in the long run.
  - **Immediate and Symptomatic Solution:** In the short term, sustainability-based governance, policy, business frameworks and appropriate technology will have to be developed and implemented.

Fine, spiritual knowledge is the ultimate solution of all human problems.

Integrating spiritual spiritual knowledge with worldly knowledge in a child’s education will ensure permanent sustainability in the long term.

But where is this spiritual knowledge available?

Where is Spiritual Knowledge Available?

- Scriptures of various religions in the world
  - They contain the universal spiritual knowledge explained in the region-specific and people-specific context.
  - Mostly, it is mixed with some moral codes.
  - The differences between scriptures are due to the different contexts in which they were revealed; they are not differences in the essential knowledge.
  - However, the concepts are extremely subtle and complex and we are unfamiliar with the context and background in which that knowledge was revealed. So, mere reading of the scriptures can often lead to a misunderstanding of the actual concepts. Correct interpretation requires great expertise.
  - Nevertheless, they are the repository of valid spiritual knowledge.
  - They can be considered to be the standard against which the validity of any concept or theory in spirituality must be tested.

Where is Spiritual Knowledge Available?

- Teachers from scriptural teaching traditions
  - The subtle and complex concepts in the scriptures, require high preparation of the receiver and an able teacher.
  - Almost all religious and philosophical schools have their own teaching traditions taught by trained teachers.
  - They are generally mixed with the religious aspects of that tradition, which are generally helpful for the student.
  - This traditional learning can provide some basic exposure but not the highest spiritual knowledge, nor the highest spiritual accomplishment.

Where is Spiritual Knowledge Available?

- **Sadguru: highest accomplished Master and embodiment of Divinity.**
  - Only he who has personally and practically accomplished the concepts being taught, can give the highest spiritual knowledge and enable practical accomplishment in the student.
  - e.g. Only a coach who has himself succeeded at the Olympics can train another sportsman for the Olympics.
  - Such a Guru (teacher) is said to be the Sadguru (Sat+Guru) — the true Guru, who is the embodiment of Divinity.
  - Correctly identifying a genuine Sadguru and learning from Him is the surest path to the highest spiritual success.

Sources of Spiritual Knowledge

Source	Quality	Max level achievable (analogical)
Learning from Sadguru	**Best**	**PhD**
Learning from traditional guru/acharya	Better	M.Tech
Self-study of scriptures	Good	B.Tech

As teachers, we are married to knowledge and truth.

Even as we grope in the dark ourselves, we are obligated to find the light and lead society to it.

Extra Slides

On some practical steps and principles in designing sustainable communities.

Principles of Sustainable Technology and Business Development

- Question the need for any technology in the first place.
  - Is it even a basic need?
  - Can it be satisfied by a commonsense solution rather than using technology. (e.g. old curtains can be stitched into cloth shopping bags. The technology of the non-recyclable UHMPE carry bags is not even necessary!
  - Do you really need to develop the technology to grow strawberries in a semi-arid place? Indian jujube (ber) grows wild in these places without irrigation and is far more nutritious!
  - Even the consumer can enquire: “Do I really need a plasma television in every room to feel entertained or do I actually crave for the care and love of my family?”

Principles of Sustainable Technology and Business Development

- Find the lowest technology solution to satisfy the need
  - E.g. A zero technology kitchen garden plot of a few square meters provides tasty organic vegetables and fruits on inputs of (i) your own kitchen organic waste and, (ii) greywater from your own kitchen and shower rooms. It solves several problems to a substantial extent: food and nutrition, freshwater scarcity, solid waste management and domestic effluent treatment. Besides, its is a great way to enjoy togetherness with your family and reduce TV watching and obesity.
  - E.g. Using herbal items like soapnut, shikakai, neem, vinegar, etc. as cleaners and disinfectants, eliminates the need for a vast gallery of chemical industries. These plants can grow even without irrigation in your backyard or neighborhood and serve many ecosystem functions. If you use these natural non-toxic cleaners, your greywater can be used directly for garden plants, without any effluent treatment.

Principles of Sustainable Technology and Business Development

- Rethink (and re-engineer if required) systems, processes and actions at all levels.
    - All engineering systems involving ecosystem components have to be developed on sound ecological principles.
    - e.g. agriculture can be replaced by agro-ecosystems like food forests.
    - A Systems Approach to Waste Management

Principles of Sustainable Technology and Business Development

- Localize material requirements (shorten the supply chain):
  - Food requirements can be satisfied within a 5 km-radius.
  - Clothing, building materials etc. within a 100 km radius.

- Globalize information:
  - Information communications technology, can reduce materials use drastically.
  - It can save unnecessary human transportation.
  - It can help design simple and more efficient products, structures, processes and systems.

Principles of Sustainable Technology and Business Development

- For industrial production:
  - Develop “Industrial Symbiosis Networks” for industries where ever possible so that wastes and byproducts of one industry can be utilized by another leading to an overall minimization of the resources required and waste generated. Preferably a closed cycle supply chain.
  - Within each industry, process and resource integration should be implemented, whereby waste products, heat and water from one process should be fed to another process.
  - For each process, proper design, monitoring, and control to be done to maximize efficiency.
  - All industries to follow strict environmental and personnel health and safety standards.

Principles of Sustainable Technology and Business Development

- Life cycle analysis for all products and due labeling.
- Internalizing environmental and social costs in product cost.
- Reverse supply chain for recycling products
- Responsible product advertising
- Responsible media
- Similar principles for policy and governance and every

Central Message for Students

- All environmental and social problems are inextricably connected. No isolated solution is possible.
- Hence, sustainable development (the confluence of the 3 preoccupations) is the goal. Present unsustainability is the problem.
- Most common solutions to unsustainability (based on technology, management, legislation, regulation reforms etc.) are superficial, partial and temporary.
- A true and permanent solution requires a fundamental approach.
- Unsustainability is a moral issue. True sustainability can be achieved only if all the above solutions are implemented in a society of high moral standards.
- Morality must be based on a firm foundation of spirituality; else it is flimsy.
- Society, firmly grounded in spiritual knowledge (leading to morality), must develop appropriate technology, organizations, policies and governance principles.

Outline

A complete restructuring in technology, governance, policy and business is ***necessary*** for sustainable development; ***but not sufficient*** because:

- Our understanding of natural systems and human behavior is too limited. Hence, technological, management or other solutions can go either way—They might solve problems or lead to new ones.
- Moreover, it is ***people*** who are responsible for the overconsumption of resources and corruption and injustice in society. Man is the common factor in:
  - man-environment interactions—leading to environmental problems
  - man-man interactions—leading to social problems.

Sustainable Resource Management

Outline

- Motivation
- Conventional Approach
- Systems Approach: Principles for Optimizing the Waste Management Method
- Example: Simple vs. Complex Systems
- Amplify Benefits
- Waste Disposal Priorities
  - Plastic Waste
  - Dry Biomass
  - Human Waste
  - Animal Waste
  - Organic Waste
- Towards a Sustainable Home

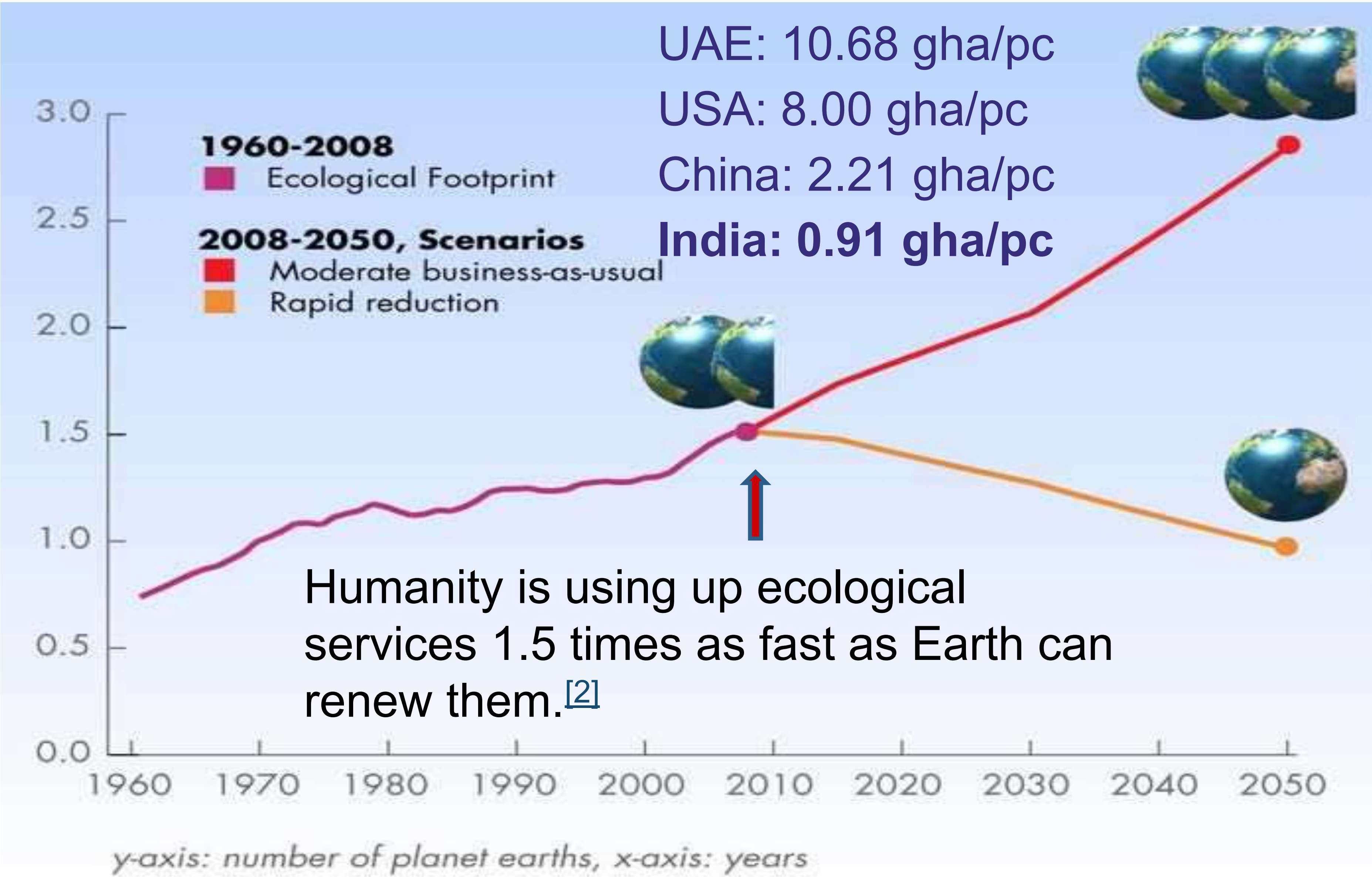
Renewable and Nonrenewable Resources

- **Perpetual/Continuous** resources are those that remain available in the same measure for an indefinitely long time e.g. Solar, Wind, Geothermal, Wave power
- **Renewable resources** can be replenished over fairly short spans of time, such as months, years or decades. E.g. Biomass energy, biofuels, Hydroelectric power generation
- **Nonrenewable resources** take millions of years to form and accumulate, e.g. All fossil fuels like coal, oil, natural gas; uranium, thorium (nuclear fuel)

Ecological Footprint > Earth's Biocapacity

- **Ecological Footprint is the amount of biologically productive land and sea area needed to supply the resources a human population consumes, and to assimilate associated waste.**
- **The ability of Earth to replenish the used (renewable) resources and absorb or deactivate the waste and pollution caused by our activities is called as Earth's biocapacity.**
- It is reported in area units.
- It attempts to quantify the human demand on the Earth's ecosystems.
- *Can be calculated for an individual, a family, an organization, a country or the entire human population on the earth.*

Humanity's Ecological Footprint



World Footprint www.footprintnetwork.org

Ecological Footprint > Earth's Biocapacity

- Human activities use up or degrade Earth's resources and generate waste and pollution but Earth regenerates/restores (biocapacity).
- Why is humanity's ecological footprint large?
  - High resource extraction.
  - Generation of large amounts of waste and pollution.
- How can the footprint exceeds the area of the earth?
  - Earth's biocapacity is only the renewable biocapacity (renewable resources).
  - It does not include the non-renewable resources.
  - But we are using a lot of non-renewable resources.
  - To restore the damage done by their use, we need an area in excess of Earth's surface area.

Ecological Footprint > Earth's Biocapacity

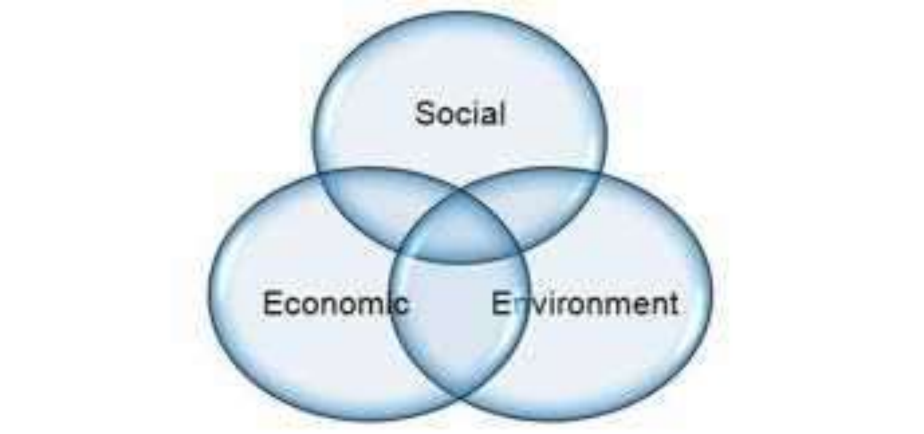
- Human population and the demand of resources is increasing at alarming rates.
- But natural resources are dwindling rapidly.
- Forests, grasslands, wetlands, mangroves, coral reefs and all ecosystems are degrading.
- Then there is the problem of waste and pollution
- At some point an abrupt collapse of these ecosystems is likely.
- The services provided by them are degrading and might cease abruptly, with tragic consequences.

This model of development is not sustainable.

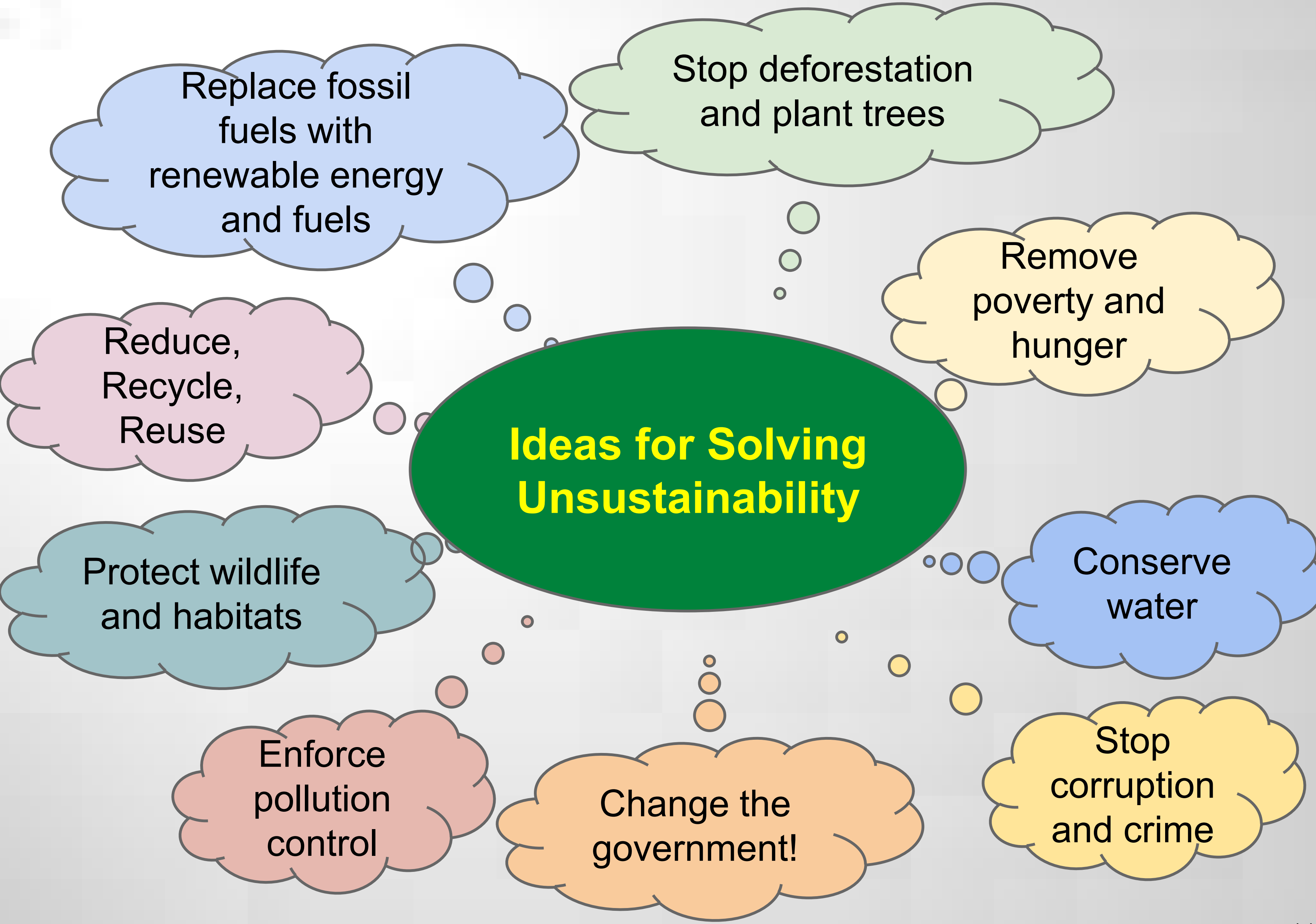
We need SUSTAINABLE DEVELOPMENT

Sustainable Development (SD)

- SD is the **economic development** to meet **human needs** while preserving the **environment.**
- Meet needs into the indefinite future.
- Present economic growth is unsustainable since it leads to social inequities and environmental damage.
- Economy, Society, Environment: 3 interdependent and mutually reinforcing pillars of SD.



How do we bring about sustainability?


Ideas for Solving Unsustainability
Replace fossil fuels with renewable energy and fuels
Stop deforestation and plant trees
Remove poverty and hunger
Reduce, Recycle, Reuse
Protect wildlife and habitats
Conserve water
Enforce pollution control
Change the government!
Stop corruption and crime

UN’s Sustainable Development Goals

https://en.wikipedia.org/wiki/Sustainable_Development_Goals

These ideas are alright.

But if we all try to work on each one of them independently, it won’t lead to sustainability.

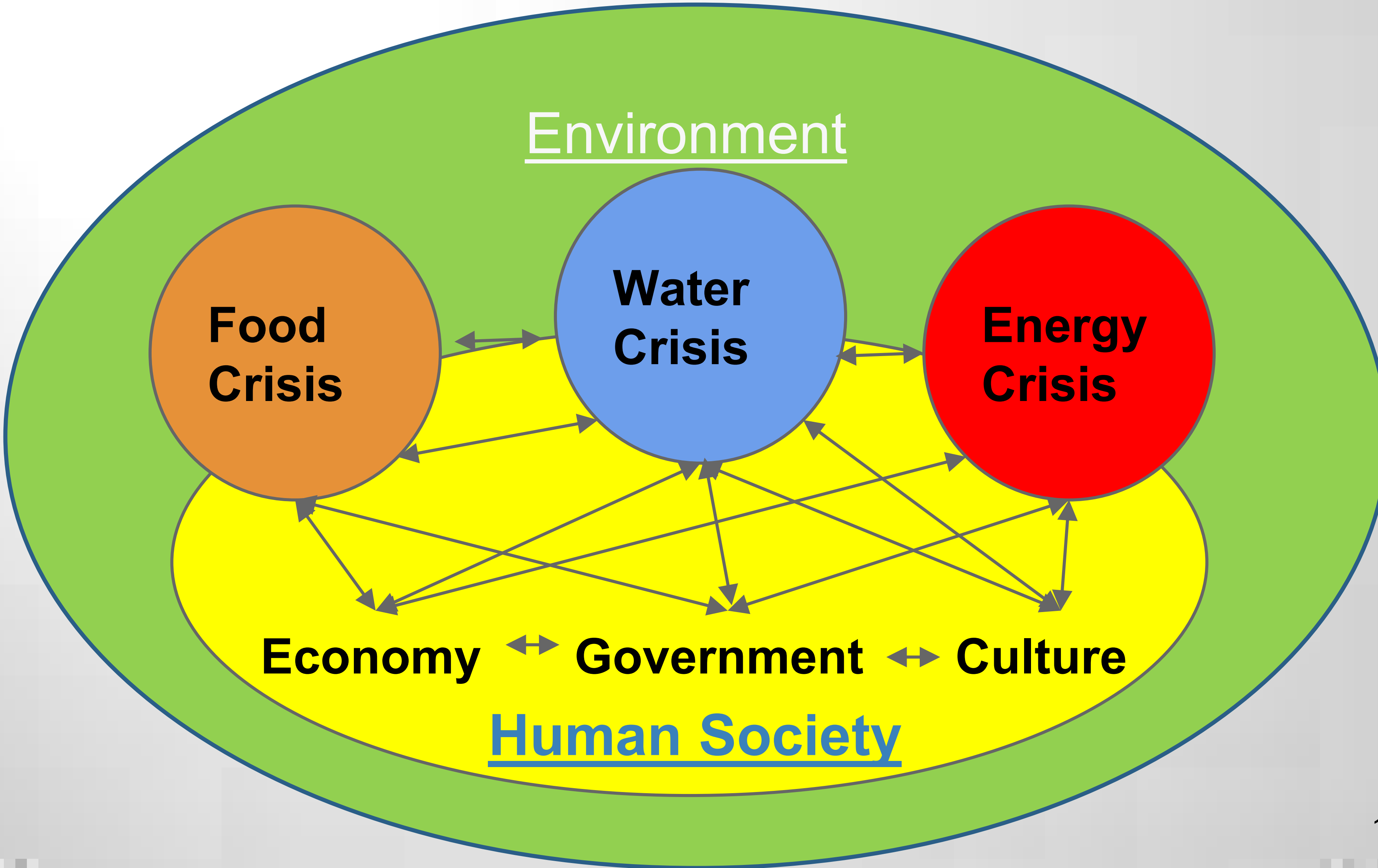
Why?

Because….

Outline

- Interrelations in Nature
- Present Unsustainability
- Sustainable Development
- Inadequacy of a Fragmented Approach
- Design for Sustainability
  - Integrated Resource Management
- Requirements for Sustainability
- Consumption, Sustainability and Well Being
- Fundamental Necessity of Education for Sustainability

Interactions in Socio-Environmental Problems



Achieving Sustainable Development

Then how to achieve sustainability?

Let's begin by trying to see some of the ways by which sustainability can never be achieved...

What is not sustainable

- Sustainability “greenwash”:
  - A company or organization claiming to be “green” through advertising and marketing instead of actually implementing business practices that significantly minimize environmental impact. [ref]
  - e.g. A petrochemical company adopts a few efficiency measures, changes the color of its logo to green, launches a worldwide ad campaign announcing themselves as a “sustainable company.”
- Mere compliance with regulations:
  - Meeting pollution control board norms.
  - e.g. a coal-fired power plant can never become sustainable even if it meets emission norms.

What is not sustainable

- Superficial solutions will not be enough
  - E.g. merely tuning up your car engine does not solve the air pollution problem.
  - E.g. merely avoiding plastic bags does not solve the waste problem.
  - If each person takes one small step, humanity as a whole will take only one small step.
- Mad race for economic growth (GDP)
  - Uncontrolled economic growth is led by consumerism and fuelled by resource extraction.
  - It leads to resource depletion and pollution/waste.
  - It does not ensure social peace (high inequalities).
  - Will exhaust resources before the poorest get enough to eat!

What is not sustainable

- Solving one problem at a time might be impossible.
  - E.g. Trying to separately solve the food crisis and overpopulation as independent problems.
  - The problems are highly complex and are related.
  - Solving one without solving the other is impossible.
- Fragmented efforts towards sustainability
  - Different govt. agencies, NGOs, businesses, industries and individuals, each pursuing their own sustainability goals.
  - A comprehensive, integrated approach is needed.

Understanding Unsustainability

- **Is it possible that unsustainability is a systemic problem, since it affects all human activities?**
  - In that case, environmental and social problems can be viewed as mere symptoms of a much *deeper problem (root cause)*.
  - We will discuss this perspective towards the end of this topic.

Understanding Sustainability: Analogy of An Orchestra

- Several artists with different instruments
- What is not an orchestra:
  - Merely pretending to play the instrument. *(is like greenwash)*
  - Merely playing the prescribed notes. *(is like mere compliance with regulations)*
  - Creating as much noise as possible *(is like increasing GDP).*
  - Each musician independently playing his/her best. *(is like trying to solve one problem independently of others)*
- What is necessary for a successful orchestra:
  - Agreement to play one common composition
  - A commonly agreed-upon plan that includes the role and timing of each musician.
  - Each musician following the plan with mutual coordination.

Consensus and Understanding About SD

- Do countries and corporations agree upon the urgent need for sustainable development?
  - As of now, not adequately.
  - Most agree in principle, but differ in approach and level of commitment.
- Do thinkers, researchers, experts have an adequate understanding about sustainability and the practical steps?
  - There is some understanding of what will not lead to sustainability.
  - And the understanding of what exactly will lead to it, is still evolving.
  - More thought and mutual discussions are necessary.
  - But there have already been interesting developments...

Consensus and Understanding About SD

- Will the rest follow those who understand?
  - We'll have to see for ourselves!
  - But individual industries, groups of industries, countries and groups of countries are taking the lead.
  - Some are even setting the standards.
- Convergence of efforts is required:
  - As our understanding evolves…
  - As methodologies and approaches evolve…
  - Policies must follow suit.
  - Industries and consumers must rapidly adopt the new developments.

One thing is certain:

If we want significant progress towards sustainability, we must be prepared to make significant changes to our way of living and doing things.

What is the new understanding that we have gained about sustainability and about how to achieve it?

Outline

- Interrelations in Nature
- Present Unsustainability
- Sustainable Development
- Inadequacy of a Fragmented Approach
- Design for Sustainability
  - Integrated Resource Management
- Requirements for Sustainability
- Consumption, Sustainability and Well Being
- Fundamental Necessity of Education for Sustainability

Sustainability Must Be Designed

- Sustainability is possible only after deliberate design both at the system level and the component or process level.
- Sustainability cannot be the product of disconnected or fragmented solutions in an environment that is skewed by technology, markets and policies.
- E.g. Making biofuels from corn/sugarcane and using for transportation seems like a good idea.
    - This is because of various skewing factors such as subsidies, market prices, and policies.
    - Actually, it can worsen the food crisis and can be unsustainable.

Need for Systems Thinking

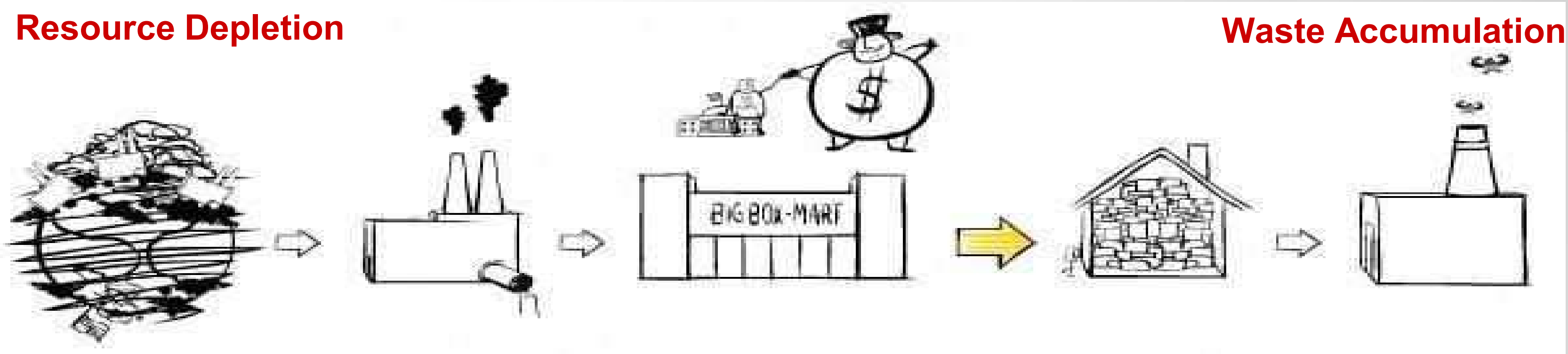
- Systems thinking is necessary for solving interconnected problems.
- The WHOLE is more than just the sum of the individual PARTS.
    - E.g. Putting together all the parts of a car in any random order does not make a functional car.
    - Each part is related to other parts in a specific way and contributes to the functioning of the whole.
    - Design is necessary both at the component level and the system level. (e.g. each part must be properly designed and the entire car must also be properly designed.)
    - Diagnosing and correcting malfunctions in complex and interrelated problems requires systems thinking.
    - Watch this video **Systems thinking: an introduction** (3.31 min)
    - Systems thinking: a cautionary tale (cats in Borneo) (3.08 min)

To apply systems thinking for solving unsustainability, let’s begin with the management of natural resources.

There is something seriously wrong with the way we presently use resources...

Present Open Loop System (Unsustainable)

Linear System

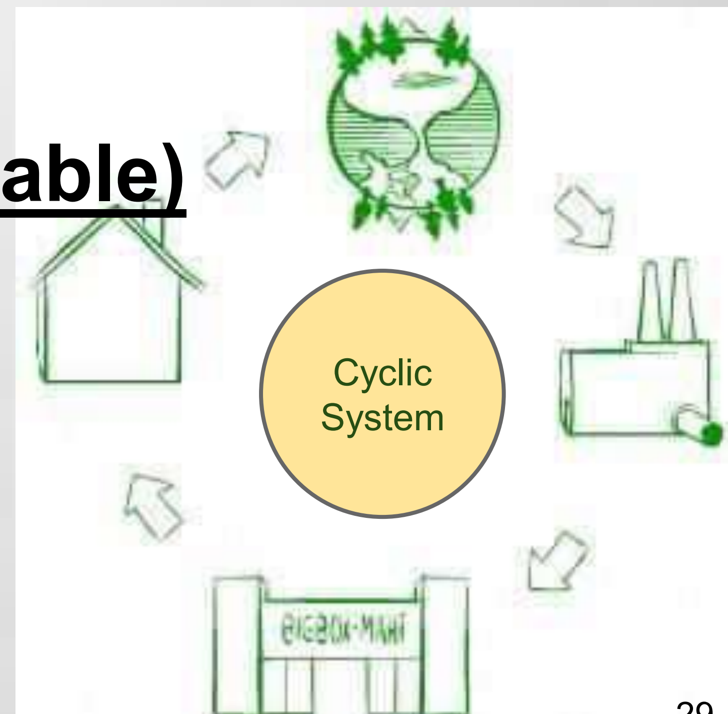


Watch the video: [The Story of Stuff] (21min) or [read transcript]

What we need is a...

Closed Loop System (Sustainable)

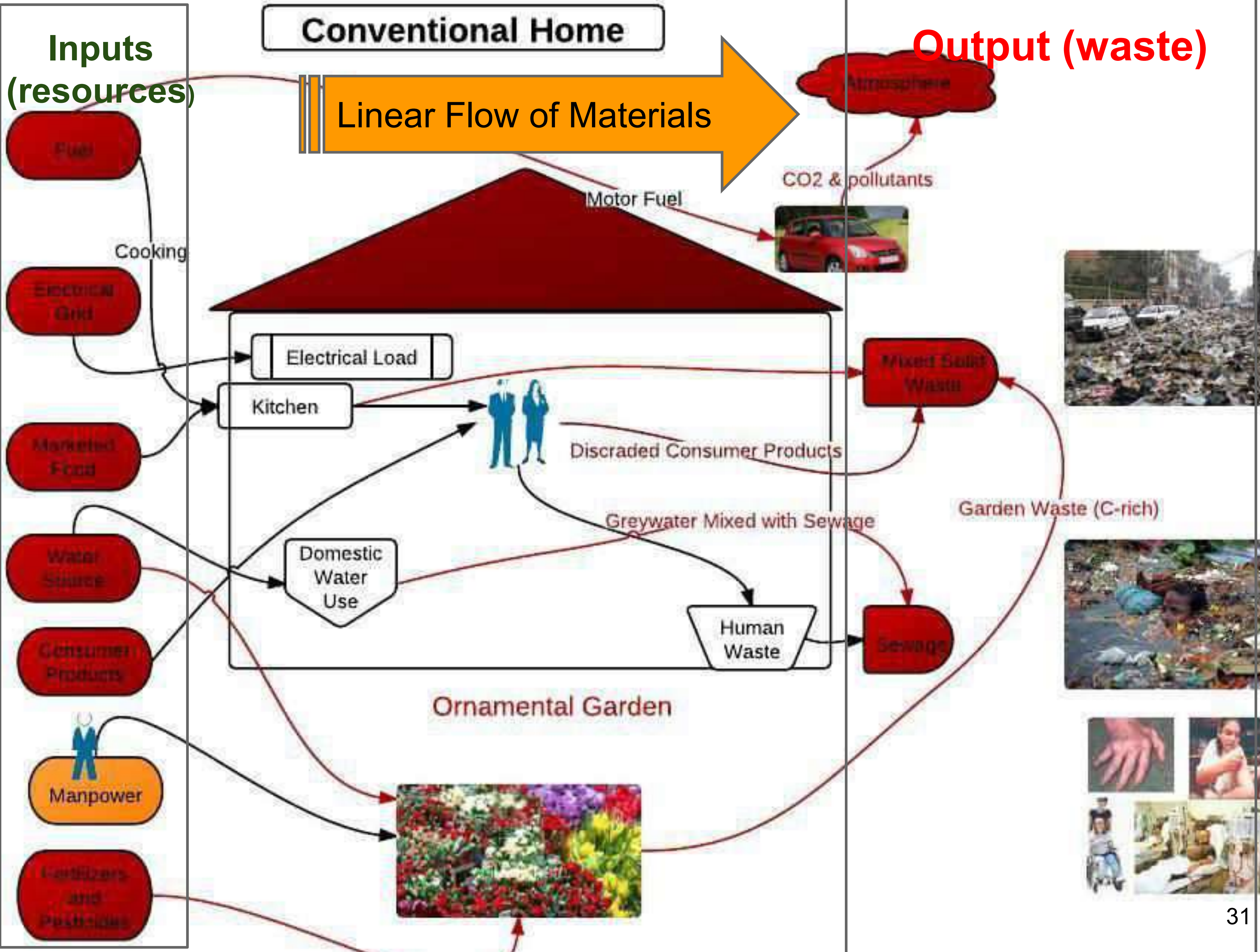
- Waste of one process is used as a resource for another process.
- Net extraction of new resources is minimized.

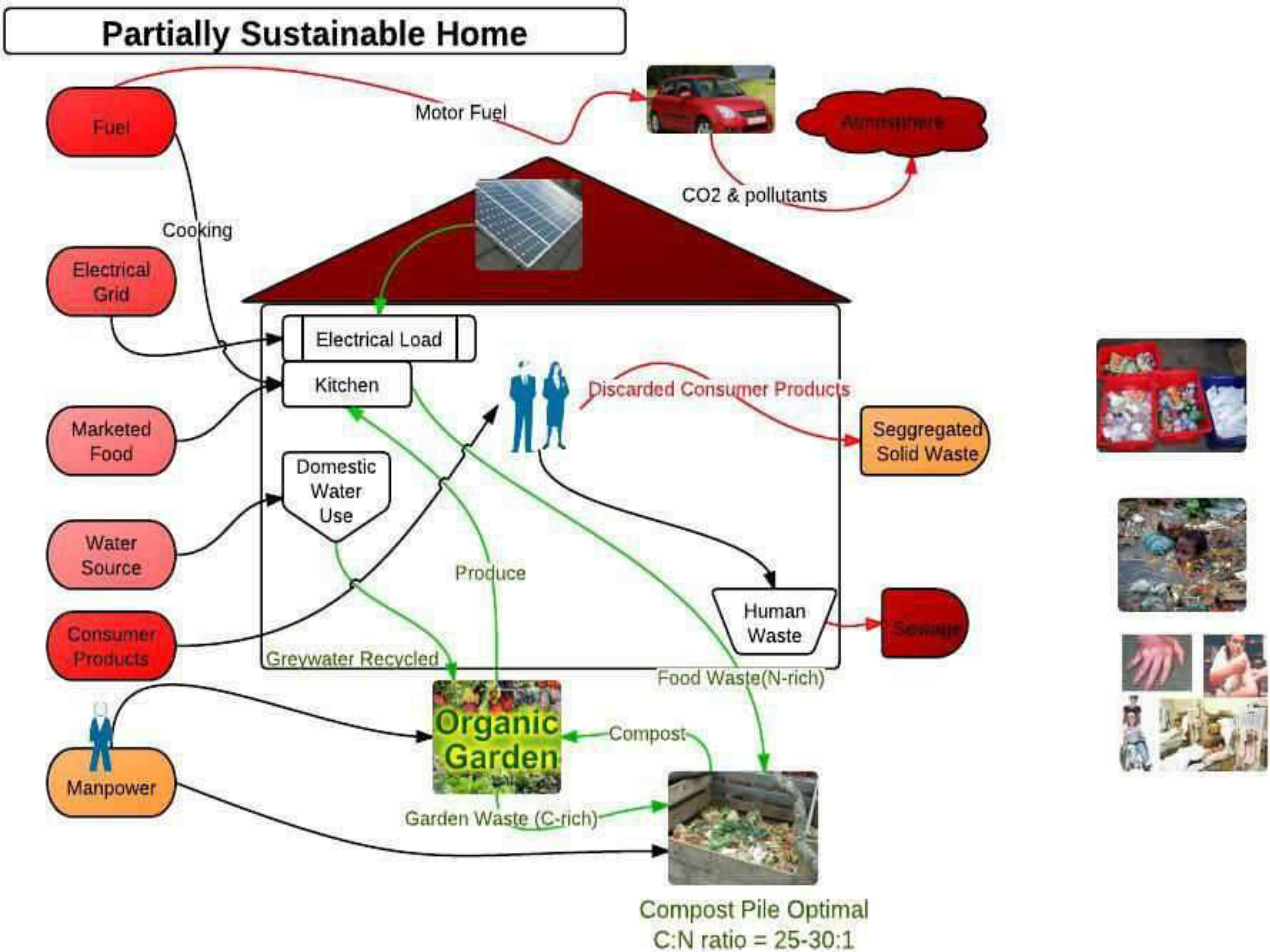


So sustainable development demands circular (cyclical) resource use at a global level.

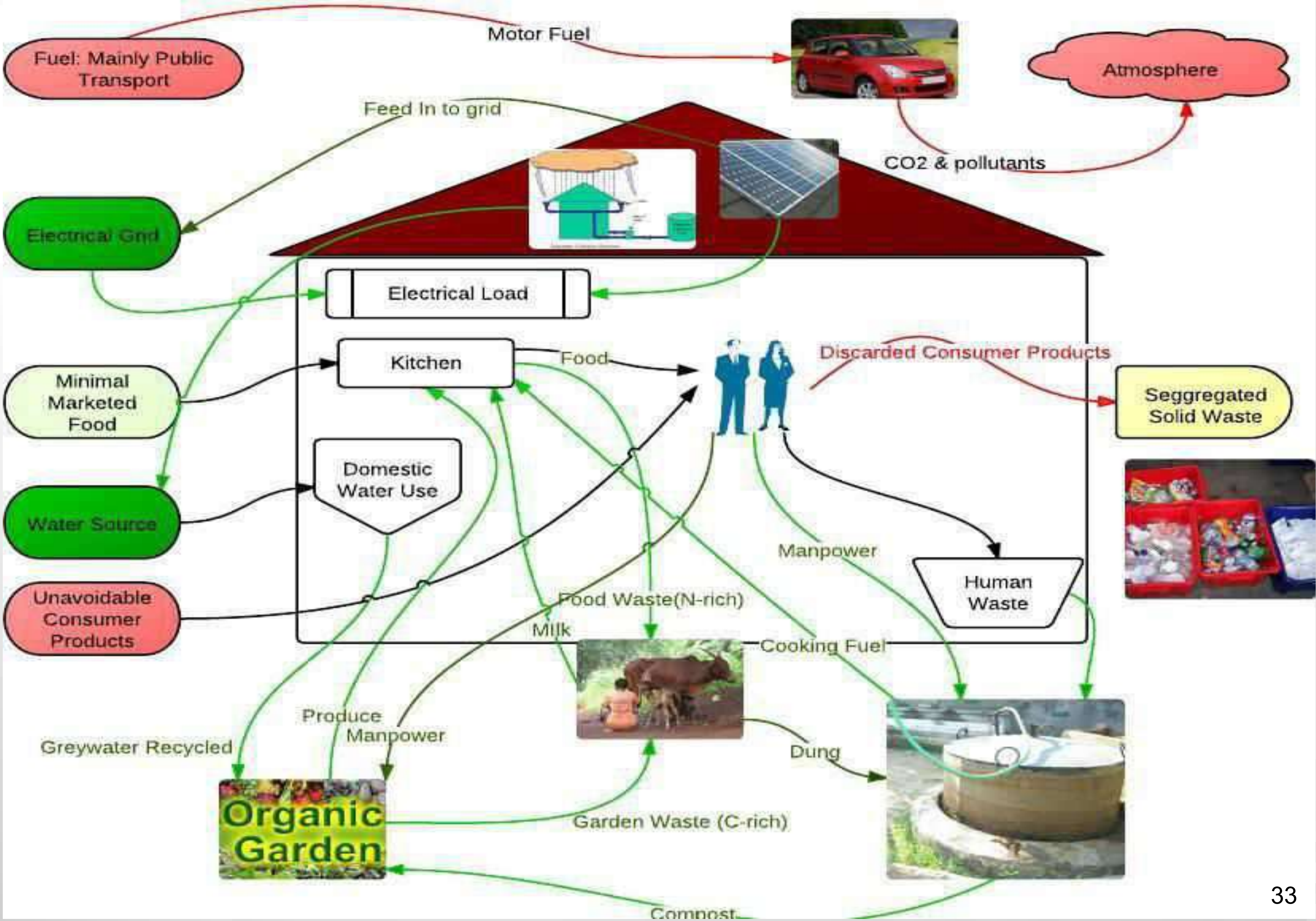
How to convert our present linear resource use system to a circular one?

Let’s understand this through the example of our home...


Conventional Home
Inputs (resources)
Output (waste)
Linear Flow of Materials
Atmosphere
CO2 & pollutants
Motor Fuel
Fuel
Cooking
Electrical Grid
Electrical Load
Kitchen
Mixed Solid Waste
Marketed Food
Discraded Consumer Products
Garden Waste (C-rich)
Greywater Mixed with Sewage
Water Source
Domestic Water Use
Human Waste
Sewage
Consumer Products
Ornamental Garden
Manpower
Fertilizers and Pesticides


Partially Sustainable Home
Fuel
Motor Fuel
CO2 & pollutants
Cooking
Electrical Grid
Electrical Load
Kitchen
Marketed Food
Discarded Consumer Products
Seggregated Solid Waste
Domestic Water Use
Water Source
Produce
Consumer Products
Human Waste
Greywater Recycled
Food Waste(N-rich)
Organic Garden
Compost
Manpower
Garden Waste (C-rich)
Compost Pile Optimal
C:N ratio = 25-30:1

Nearly Sustainable Home



The same principle can be extended to industries…

Change in Approach of Industries

- Old approach: Compliance with environmental regulations.

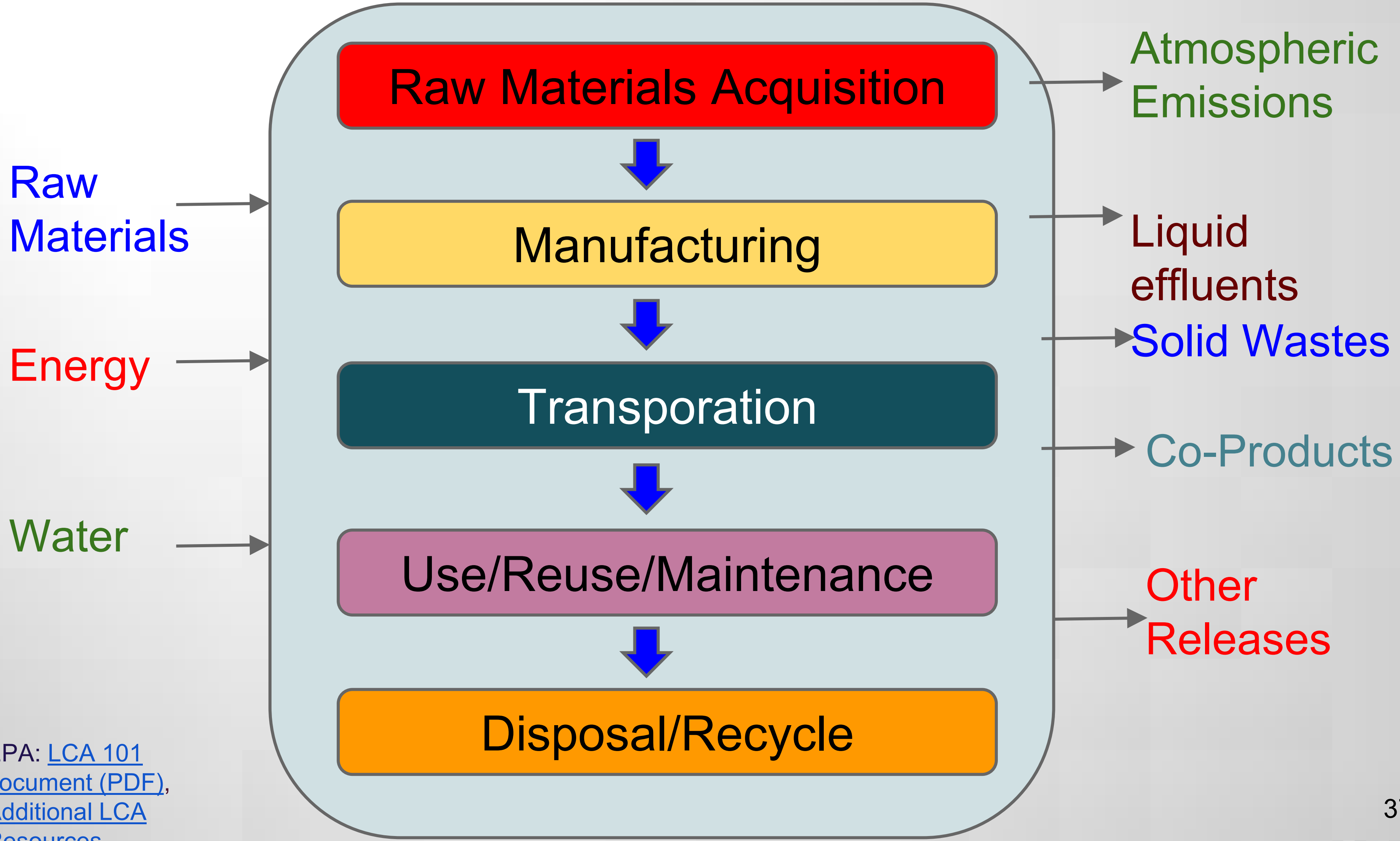
- New Approach:
  - Comprehensive pollution prevention strategies & environmental management systems.
  - Life Cycle Analysis (LCA): “cradle-to-grave” approach for assessing cumulative environmental impacts from raw material acquisition to waste disposal.
  - Design for the Environment
  - Industrial Ecology Industrial Symbiosis

Product Life Cycle Assessment

Watch Videos

- Life Cycle Assessment (4.56 min)
- *Life Cycle Assessment in 6 minutes* Crash Course series - 2011

Product Life Cycle Analysis



EPA: LCA 101 document (PDF), Additional LCA Resources.

LCA Process

- Goal Definition and Scoping:
  - Product/process definition & context of assessment.
  - Identify the boundaries and env. effects to be assessed.
- Inventory Analysis:
  - Quantify energy, water and material inputs and releases (flows).
- Impact Assessment:
  - Assess the potential human and ecological effects of the flows from the inventory analysis.
- Interpretation:
  - From inventory analysis and impacts & select the preferred product, with a clear understanding of the uncertainty and the assumptions used.

LCA Benefits

- Enables decision-makers select product/process with least env. impacts (compared with cost, performance etc.)
- Identifies the transfer of environmental impacts from one media to another
- E.g., eliminating air emissions by creating a wastewater effluent instead) and/or from one life cycle stage to another (e.g., from use and reuse of the product to the raw material acquisition phase).

LCA Limitations

- Need to carefully weigh the availability and accuracy of data, time and financial resources required against the projected benefits of the LCA.
  - Resource and time intensive.
  - Gathering some data could be difficult.
  - Inaccurate data can greatly impact the results.
- LCA will not determine which product or process is the most cost effective or works the best.
  - LCA should be used as one component of a more comprehensive decision process assessing the trade-offs with cost and performance, e.g., Life Cycle Management.

Life Cycle Management (LCM)

- Voluntary application of life cycle thinking to manage the total life cycle of an organization's product and services toward more sustainable consumption and production.
- An integrated framework of concepts and techniques to address environmental, economic, technological, and social aspects of products, services, and organizations.

Design for the Environment (DfEt)

- Design for environmental processing and manufacturing:
  - Extraction and manufacturing processes are safe for environment and people.
- Design for environmental packaging:
  - Eco-friendly packaging (reuse, recycle, efficient use).
- Design for disposal or reuse:
  - Designed for reuse, refurbishing, disassembly, recycle.
- Design for energy efficiency:
  - Low overall energy consumption throughout the product's life.

Source: http://en.wikipedia.org/wiki/Design_for_the_Environment

Design for the Environment (DfEt)

Watch Videos:

- The Secret Life of Things Animation 2010 (6 min)
- *Eco-design in 6 minutes* Crash Course series – 2011
- What You Probably Didn't Learn in Design School.(30 min)

Cradle-to-Cradle and the Circular Economy

- Beyond Reduce-Reuse-Recycle (LESS BAD)
- From LESS BAD to **GOOD**
- Design for Sustainability
- Cradle to Cradle (5.50min)
- The Circular Economy (7.00 min)
- The Circular Economy: Re-thinking Progress (3.49 min)
- The circular economy: from consumer to user (3.14 min)
- Circular Economy: Bandvulc - circular economy case study (1.30 min)
- Circular Economy: Business Case Study 1- Interface Flor (6.15min)
- Circular Economy: Business Case Study 2: Nike (5.23 min)

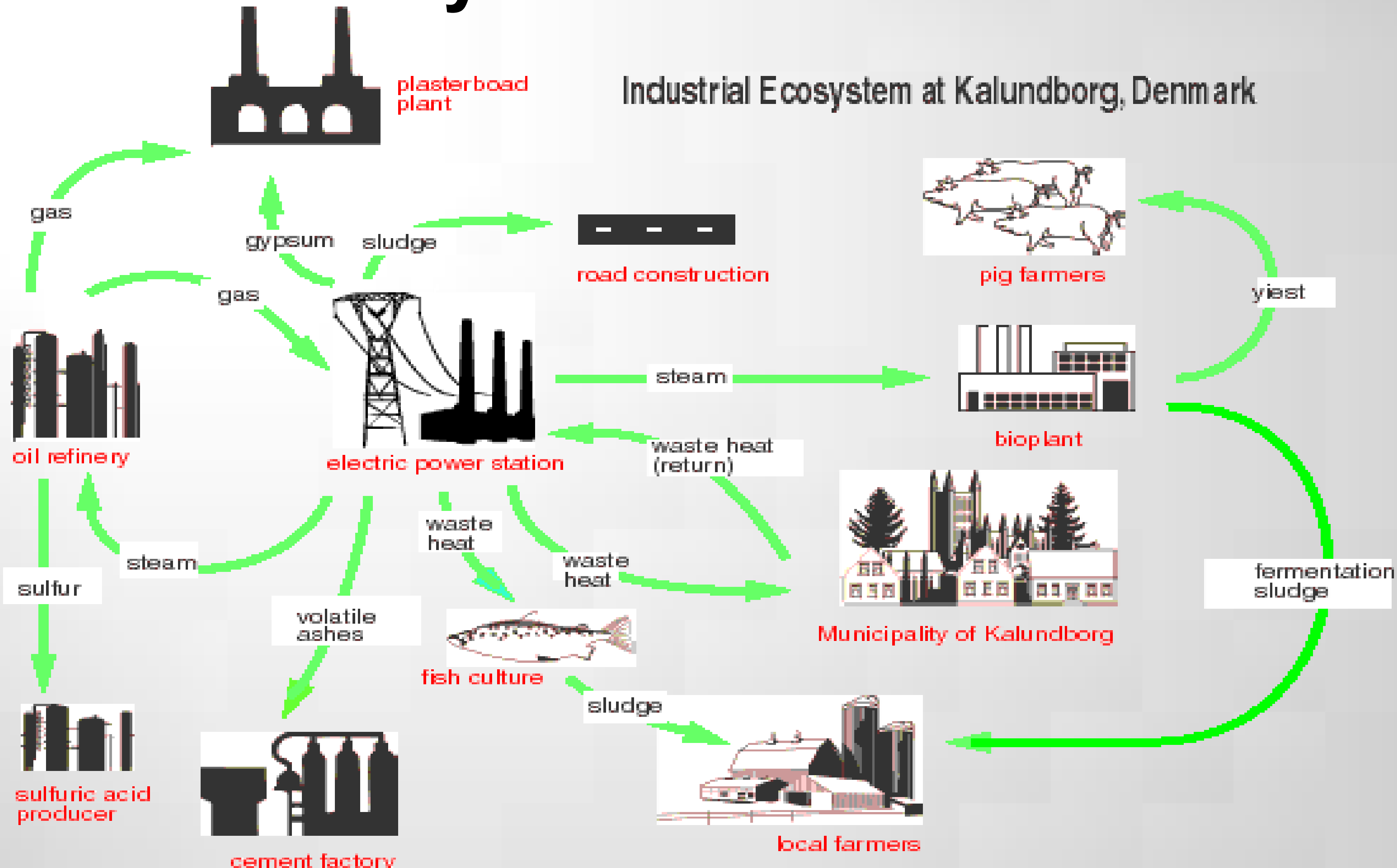
Industrial Ecology

Industrial Ecology India Part 1 (10.28 min)
Industrial Ecology India Part 2.avi (1.5 min)

Industrial Symbiosis at Kalundborg (2.36 min)

www.roionline.org

Industrial Symbiosis



One company's waste is another company's treasure

http://fleeingvesuvius.org/wp-content/uploads/2011/06/kalundborg_opt.jpeg

Environmental Management Accounting
(EMA)

Definition

There are many alternative definitions, but broadly defined…

EMA is the identification, collection, analysis, and use of two types of information for internal decision-making:

- ***Physical information*** **on the use, flows, and fates of energy, water, and materials (including wastes)**
- ***Monetary information*** **on environment-related costs, earnings, and savings**

EMA Expert Working Group of the

United Nations Division for Sustainable Development

Definition

EMA combines financial and physical data and calculates the environmental costs of companies

- Physical data on material and energy input, material flows, products, waste and emissions → PEMA
- financial data on expenditures, costs, earnings, savings related to company activities with potential environmental aspects or impacts → MEMA

Why was EMA Developed?

- EMA was conceived in recognition of some of the limitations of conventional practices for informing environmental management decisions
  - insufficient tracking of energy, materials, and wastes
  - "hiding" of costs in overhead accounts and elsewhere in the accounting records
  - lack of data on future and less tangible costs in the accounting records at all
  - Insufficient communications between the accounting and other departments/staff, e.g., production, environmental, research…

PHYSICAL INFORMATION

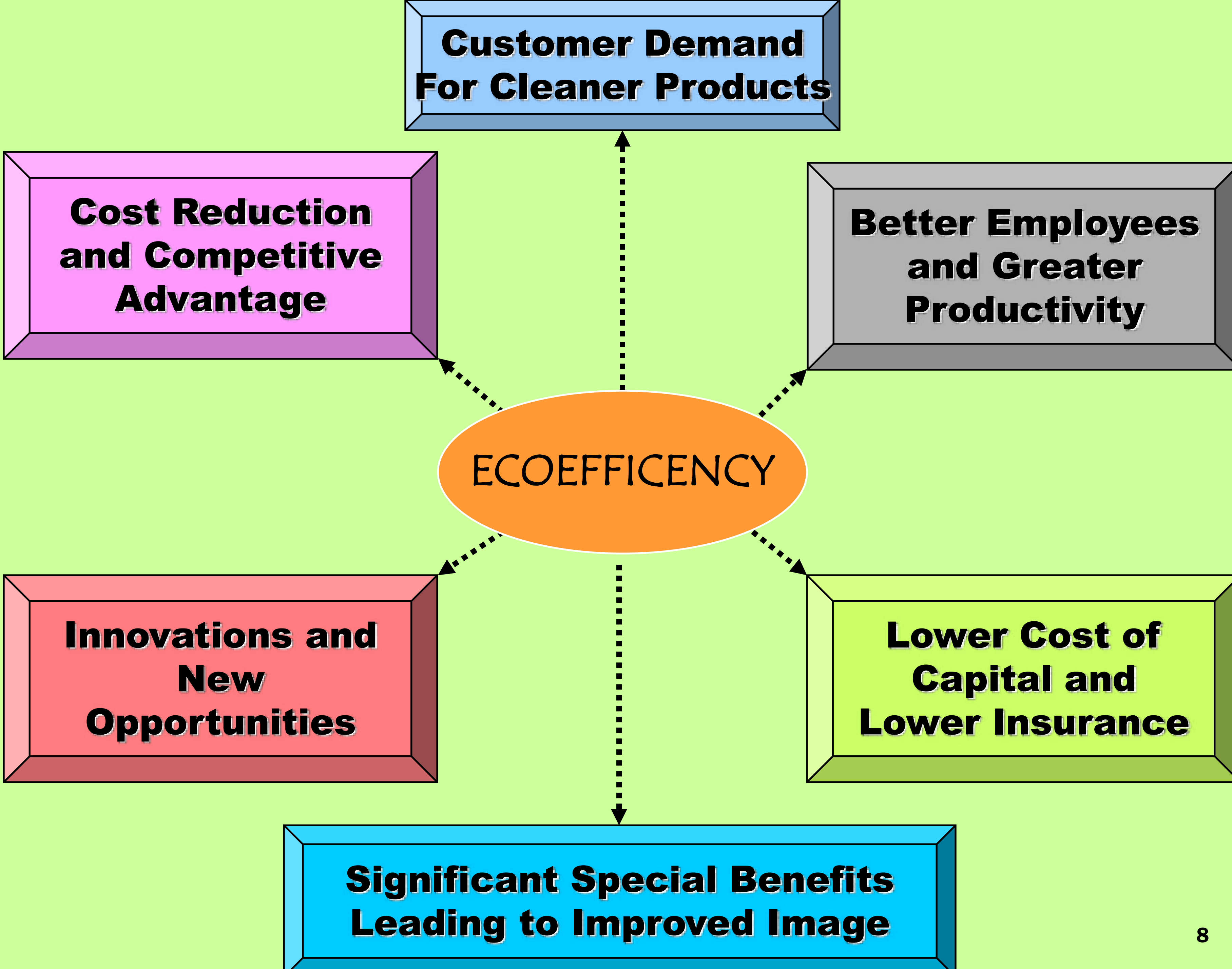
- ✓ **Flow of energy, water, materials and waste (MEFA)**
- ✓ **Physical Information**
  - Materials Inputs
  - Product Outputs
  - Non-Product Outputs (Waste and Emissions)
- ✓ **Materials/Mass Balances**
- ✓ **Physical Environmental Performance Indicators**

MONETARY INFORMATION

- ✓ ENVIRONMENT-RELATED COSTS AND EARNINGS
- ✓ **Cost Categories**
  - Waste & Emission Control Costs
  - Prevention & Other Environmental Management Costs
  - Research & Development Costs
  - Materials Costs of Non-Product Outputs
  - Materials Costs of Product Outputs
  - Less Tangible Costs
- ✓ **Monetary Environmental Performance Indicators**
- ✓ **Environment-related Earnings and Savings**
- ✓ **Distribution of Costs by Environmental Domain**

The Benefits of Ecoefficiency

- *Ecoefficiency* **essentially maintains that organizations can produce more useful goods and services while simultaneously reducing negative environmental impacts, resource consumption, and costs.**


Customer Demand For Cleaner Products
Cost Reduction and Competitive Advantage
Better Employees and Greater Productivity
ECOEFFICENCY
Innovations and New Opportunities
Lower Cost of Capital and Lower Insurance
Significant Special Benefits Leading to Improved Image

Environmental Quality Cost

- *Environmental costs* are costs that are incurred because poor environmental quality exists or may exist.

Environmental costs can be classified in four categories: prevention costs, detection costs, internal failure costs, and external failure costs.

Environmental Costs Are Often Underestimated

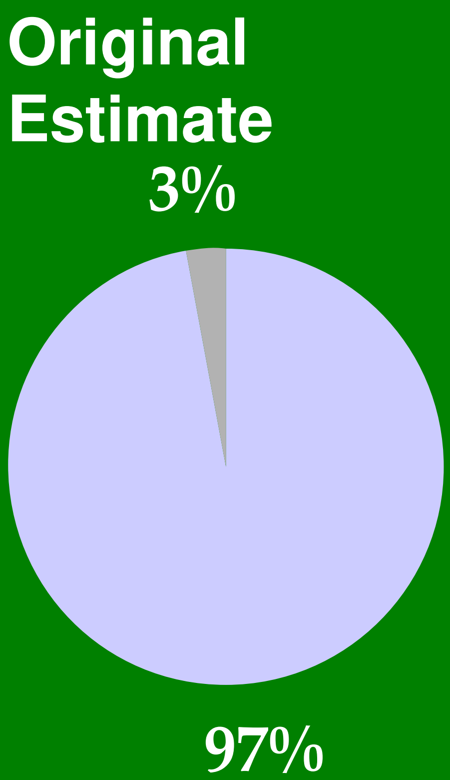
- Research Findings:
  - For every dollar of waste cost that companies actually measure, another 2 to 3 dollars of cost are" hidden" in the accounting records, or are not on the books at all
  - Companies typically underestimate how much waste really costs them, sometimes by several orders of magnitude
  - This applies even to big, well-managed companies

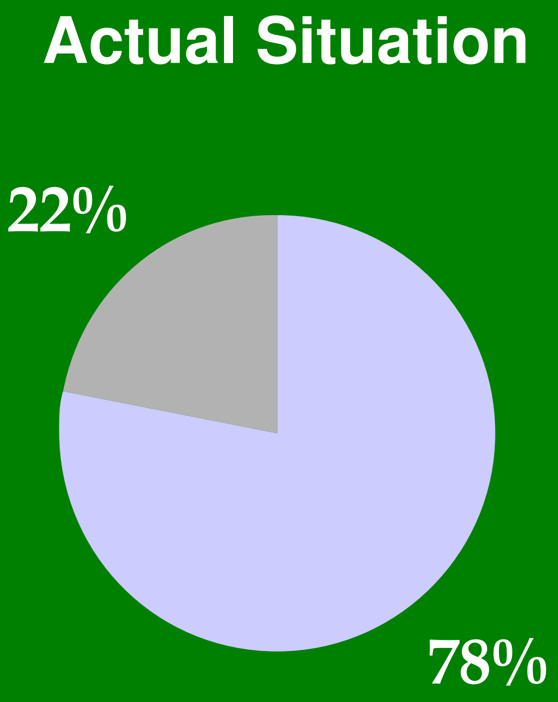
The Cost of Waste Ink at the Southwire Company

- The cost of a drum of hazardous waste ink was estimated as $50 - the average disposal cost per drum
- Upon closer inspection, the true cost of waste was discovered to be $1300 per drum, including:
  - $819 in lost raw materials (ink, thinner)
  - $369 for corporate waste management activities
  - $50 for disposal
  - $47 for internal waste handling activities
  - $16 to pay a hazardous waste tax

Environmental Costs At A Refinery

(As a percentage of operating costs,
excluding crude oil input)





Source: *Green Ledgers: Case Studies in Corporate Environmental Accounting.* World Resources Institute, May, 1995.

The Cost Iceberg

Environmental costs can be like an iceberg, with only a small part of the cost visible

Adapted from: Bierma, TJ., F.L. Waterstaraat, and J. Ostrosky. 1998. "Chapter 13: Shared Savings and Environmental Management Accounting," from *The Green Bottom Line*. Greenleaf Publishing:England.

EMA "End-uses"

EMA can provide the data needed for many environmental management initiatives

- Cleaner Production/Pollution Prevention/Green Productivity
- Design for Environment
- Environmentally Preferable Purchasing
- Environmental Supply Chain Management
- Extended Producer Responsibility
- Performance Meas. & Benchmarking
- Corporate Environmental Reporting
- etc.

EMA for Improved Capital Budgeting

- Better identification, allocation, and analysis of environmental costs improves the process by which the profitability of potential investment projects are assessed.
- Such investments include any capital project that has the major objective of controlling, reducing or preventing pollution.

Profitability Assessments of Proposed Sustainable Projects

EMA can illustrate the potential profitability of projects that utilizes preventive management strategies by doing a better job of profitability assessment:

- Comprehensive inclusion of relevant and significant costs and savings
- Improved cost estimation and allocation
- Longer analysis time horizons
- Multiple profitability indicators

Comprehensive Inclusion of Relevant Costs and Savings

(conventional and less tangible costs…)

- The cost of lost manufacturing inputs
  - lost materials, energy, labor, capital, etc.
- The cost of waste management
  - waste handling, regulatory compliance, waste treatment & disposal, etc.
- Less tangible costs
  - reduced production throughput, reduced product quality, negative company image, liability, etc.

Financial Data for White Water and Fiber Reuse Project

Costs and Savings:	*company analysis*	*improved analysis *TCA*
Capital Costs	$1,469,404	$1,469,404
Annual Savings	$ 350,670	$ 911,240
Financial Indicators:		
Payback Period	4.2 years	1.6 years
Net Present Value	$ 47,696	$2,073,607
Internal Rate of Return	17%	46%

** Total Cost Assessment: Budgeting for Pollution Prevention, Tellus Institute, 1993*

Financial Data for Quality Control Camera Project

	original analysis	*improved analysis*
Costs and Savings:		
Capital Costs	\$105,000	\$105,000
Annual Savings 1-5 years	\$ 38,463	\$ 38,463
Additional Savings Year 3		\$ 55,000
Financial Indicators:		
Payback Period	2.7 years	2.7 years
Net Present Value	-17,182	+18,981

EMA as Driver of Sustainable Investment

EMA helps companies recognize and achieve the multiple benefits of Sustainable Investments

- Reduced costs
  - increased profit margins
  - lower product prices
  - increased market share
- Reduced liability
  - improved company image
  - increased market share
  - increased access to financing and customers contracts

Benefits of EMA to Industry

- The ability to more accurately track and manage the use and flows of energy and materials, including pollution/waste volumes, types and fate
- The ability to more accurately identify, estimate, allocate, and manage/reduce costs, particularly environmental types of costs
- More accurate and comprehensive information for the measurement of performance, thus improving company image with stakeholders such as customers, local communities, employees, government and financial providers

Benefits to Government of EMA Implementation by Industry

- The more that industry is able to justify environmental investments on the basis of financial self-interest, the lower the financial, political, and other burdens of environmental protection on government.

- Implementation of EMA by industry should strengthen the effectiveness of existing government policies/regulations by revealing to companies the true environmental costs and benefits resulting from government regulations.

EMA Development

- United Nations Division for Sustainable Development's Consultative Working Group on EMA
- EMA Workbooks:
  - Environmental Management Accounting Procedures and Principles
  - EMA-Links: Government, Management, and Stakeholders
  - Policy Pathways for Promoting Environmental Management Accounting

UNDSD Expert Working Group on EMA . . .

UNDSD = United Nations Division for Sustainable Development

- EMA Working Group established in 1999
- Core members are government representatives from 30+ countries
- Other members include invited representatives of accounting associations, academia, business, etc.
- Group has met 8 times, each time in a different country
- Group has discussed many international topics of debate surrounding EMA

EMA Education…

Most initiatives to promote EMA around the world rely on voluntary adoption, with educational activities a core component:

- guidance documents
- case studies
- curriculum development & training
- software

EMA in North America and Europe

Examples of initiatives in North America and Europe that promote EMA as a tool for many environmental programs

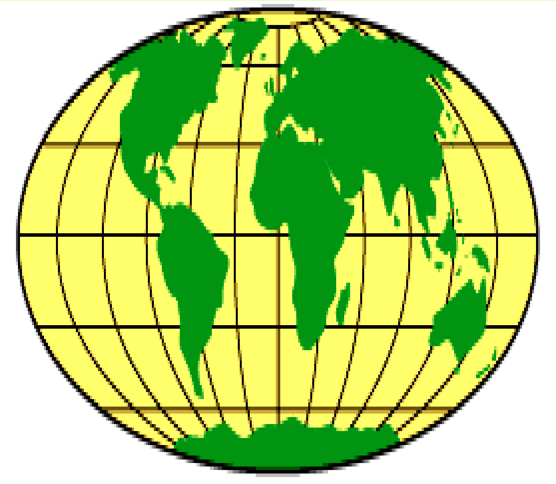
- US EPA's Environmental Accounting Project
- Environmental Canada-Quebec Regional Office's Private Sector P2 Initiative
- Graz (Austria) Department of Environmental Protection's Eco Profit Initiative
- UK Environment Agency's EMA for Financial Accountants Project

EMA in Asia

Examples of EMA and EMA-related projects and activities in Asia

- Philippine Training Course on EMA and CP supported the US-Asia Environmental Partnership (USAEP)
- Environmental Accounting Guideline published by the Ministry of Environment in Japan
- UNEP's CP Finance's Profiting from CP Course in Vietnam
- Taiwan Environmental Management Association's EMA Training Project
- Thailand Environment Institute's Workshop on EMA

STOP GLOBAL WARMING



- The End -

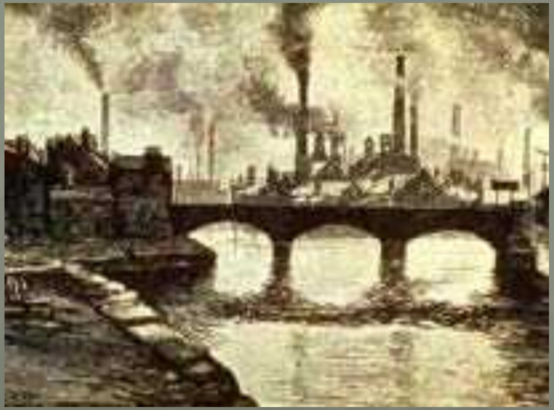
Waste and Waste Management

An Urban Perspective

By SPROUTS Environment Trust

Introduction

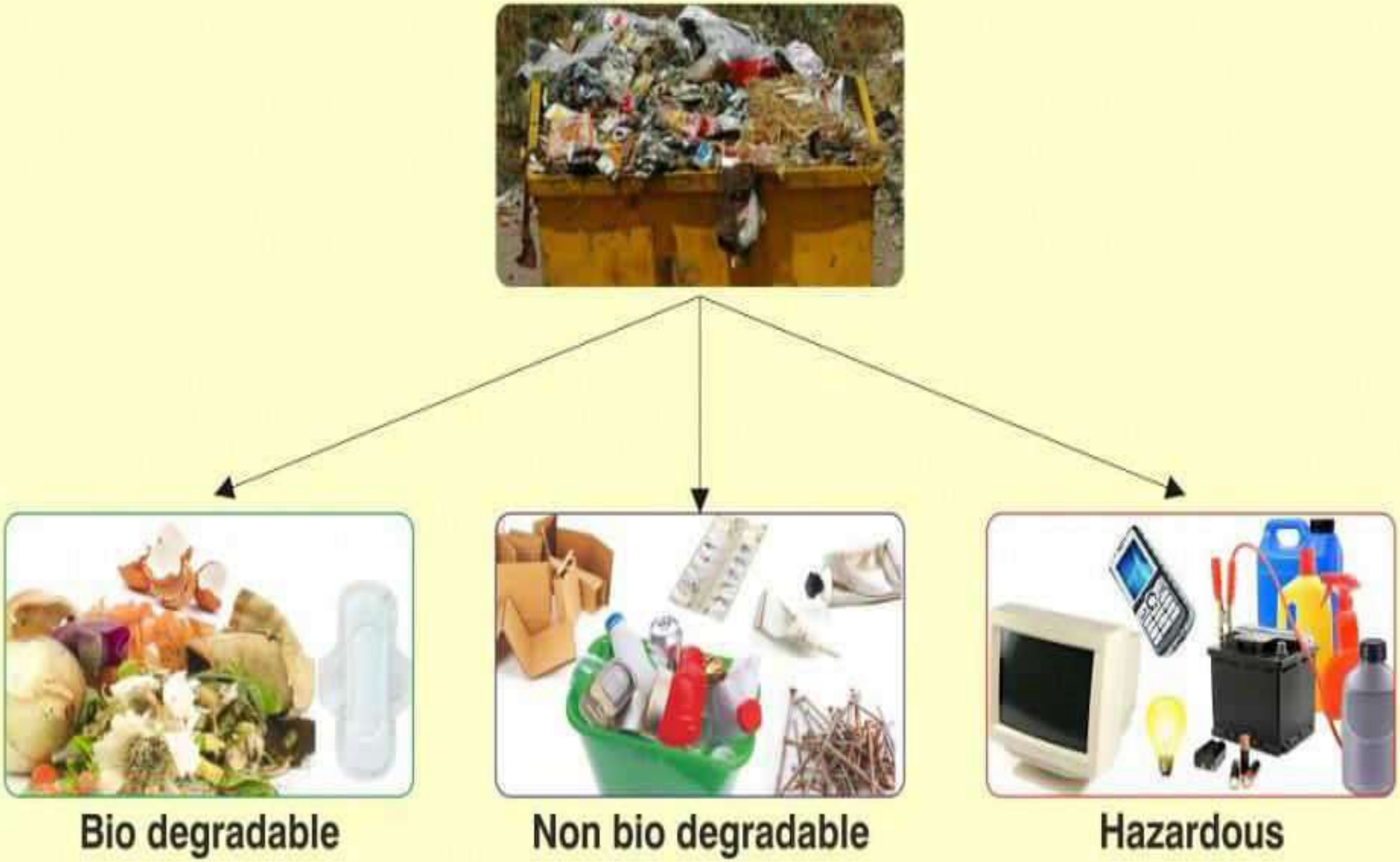
- Increasing urbanization and industrialization has led to mass consumption and over-exploitation of resources.
- With this the amount of waste generation has also increased. Unfortunately the growth in infrastructural development is not in sync with the progress in methods of waste recycling and waste management.
- We all produce waste in everything we do.

What is Waste?

- Materials that are discarded, unused and rejected as worthless or unwanted are known as waste. Also referred to as rubbish, trash, garbage, junk, et. al.
- The European Union defines waste as an object the holder discards, intends to discard or is required to discard.

3 types of waste



Forms of Waste

- Waste exists in three forms such as solid, liquid and gaseous.
- Solid waste is easily visible. It is generated from various activities like construction, industries, mining, commerce, offices and domestic use.
- Liquid and Gaseous waste is also generated from these sources.

Classification of Waste

- Biodegradable & Non-biodegradable –

Biodegradable waste is also know as organic waste. Biodegradable wastes are decomposed by earthworms, insects, fungi and microbes. The degraded material again enters the biogeochemical cycles. Most of the household waste and agriculture waste is biodegradable. Such waste is also known as 'wet waste'.

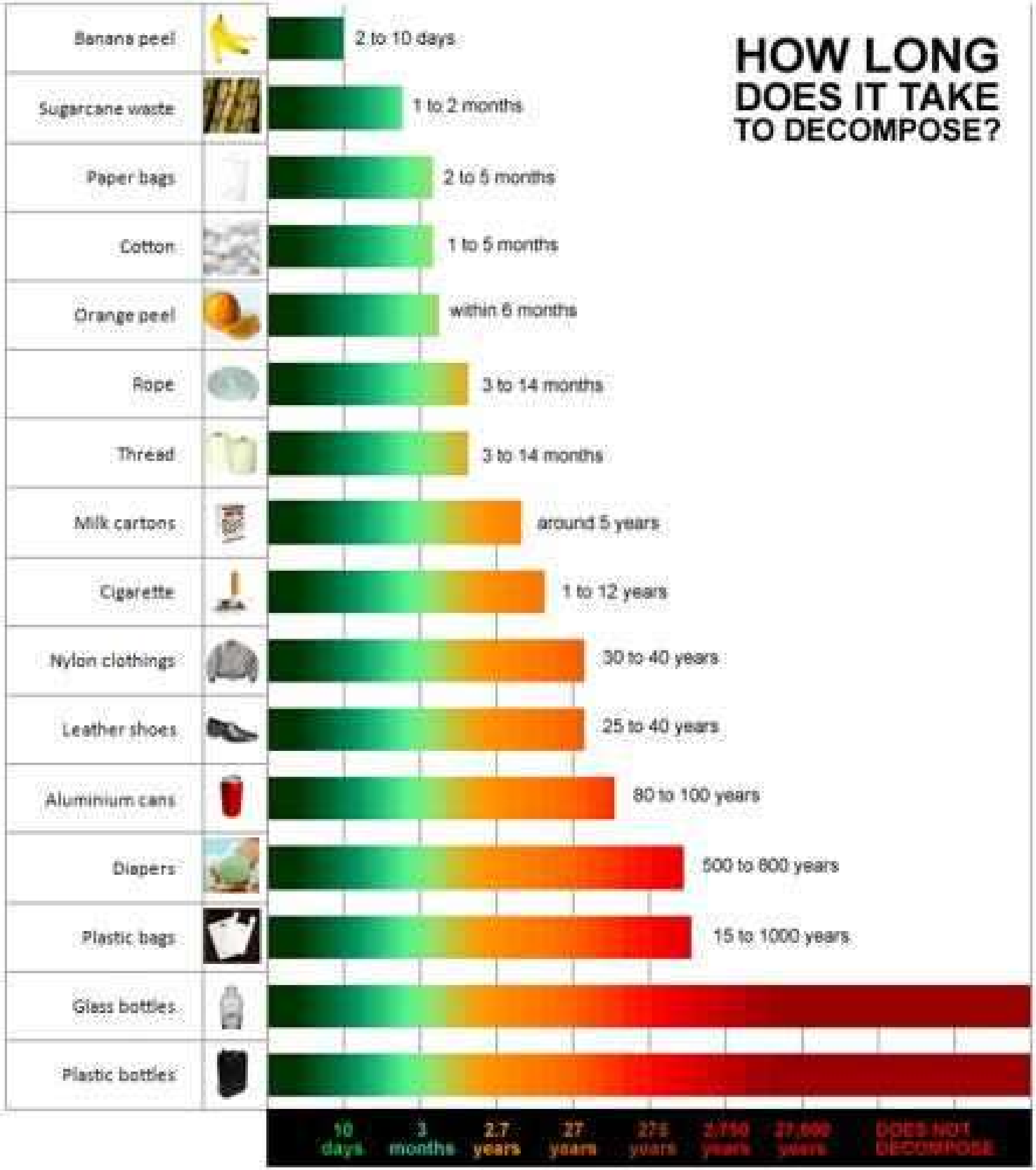
Non-biodegradable waste consists of synthetic materials like plastics, thermocol, rayon, nylon, aluminium foil, metal, glass, etc. It also includes different electronic waste. Non-biodegradable waste contains recyclable and non-recyclable components

Classification of Waste

- Hazardous & Non-Hazardous –

Hazardous waste materials are those materials which are highly toxic to humans, animals and plants. Some hazardous wastes can cause genetic disorders. Certain types of hospital wastes and industrial wastes are considered hazardous. Certain types of house hold wastes are also hazardous. Such waste requires cautious handling.

Non hazardous wastes include municipal and household waste, construction and domestic waste etc. It may further be classified into Biodegradable & Non-biodegradable wastes



Source: http://socyberty.com/issues/strange-trash-facts/