Wollo University

Department of Geology

Environmental Geology (Geol 4141)

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Course Content

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Global environmental issues and challenges

Development-resources-sustainability

Population and the environment

Population-resource-environment linkage

Earth materials, systems and cycles

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Internal structure and composition of the earth

Origin and distribution of earthquakes, tsunamis

Measurement of earthquakes, earthquake magnitude, Earthquake Intensity

Effects of Earthquakes, Predicting earthquakes and earthquake risks

The response to earthquake hazards, mitigation measures

Earthquake hazard in Ethiopia

Chapter 3: Natural Hazards: Volcanic and its hazards

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Predicting volcanic hazards and mitigation measures

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Volcanic hazards in Ethiopia

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Urbanization and flooding

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Chapter 5:Natural Hazards: Landslide and its hazards

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Slope stability

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Landslide hazard in Ethiopia

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Restoration & rehabilitation technologies, cost-benefit analysis

Chapter 1: Introduction (3hrs)
Chapter content

- Introduction
- Global environmental issues and challenges
- Development-resources-sustainability
- Population and the environment
- Population-resource-environment linkage
- Earth materials, systems and cycles

1.1. Definition, Scope, Tools

Environment is a broad term that includes the total set of circumstances that surround an individual or a community.

- It includes all the physical conditions such as air, water, gases, soil, forest, landforms etc that affect the growth and development of an individual or community or any form of life.

- All of the external factors affecting an organism.

These factors may be other living organisms (biotic factors) or nonliving variables (abiotic factors), such as temperature, rainfall, day length, wind, and ocean currents.

- The interactions of organisms with biotic and abiotic factors form an ecosystem.
- Even minute changes in any one factor in an ecosystem can influence whether or not a particular plant or animal species will be successful in its environment..

Environmental science is the study of the interaction of humans with all aspects of their environment (its physical/ geological, atmospheric and biological components).

- it considers both the debits (impacts) and credits (benefits) of our coexistence with other species and environments.

- In other words, environmental science gives us the scientific basis so as to maximize human success, while minimizing its adverse impacts on other elements of the environment.

Scope

-Scientists study the long-term consequences of human actions on the environment, while environmentalists—professionals in various fields, as well as concerned citizens—advocate ways to lessen the impact of human activity on the natural environment.

- Environmental science almost invariably proposes problems of extreme complexity, typically characterized by strongly nonlinear evolution dynamics.

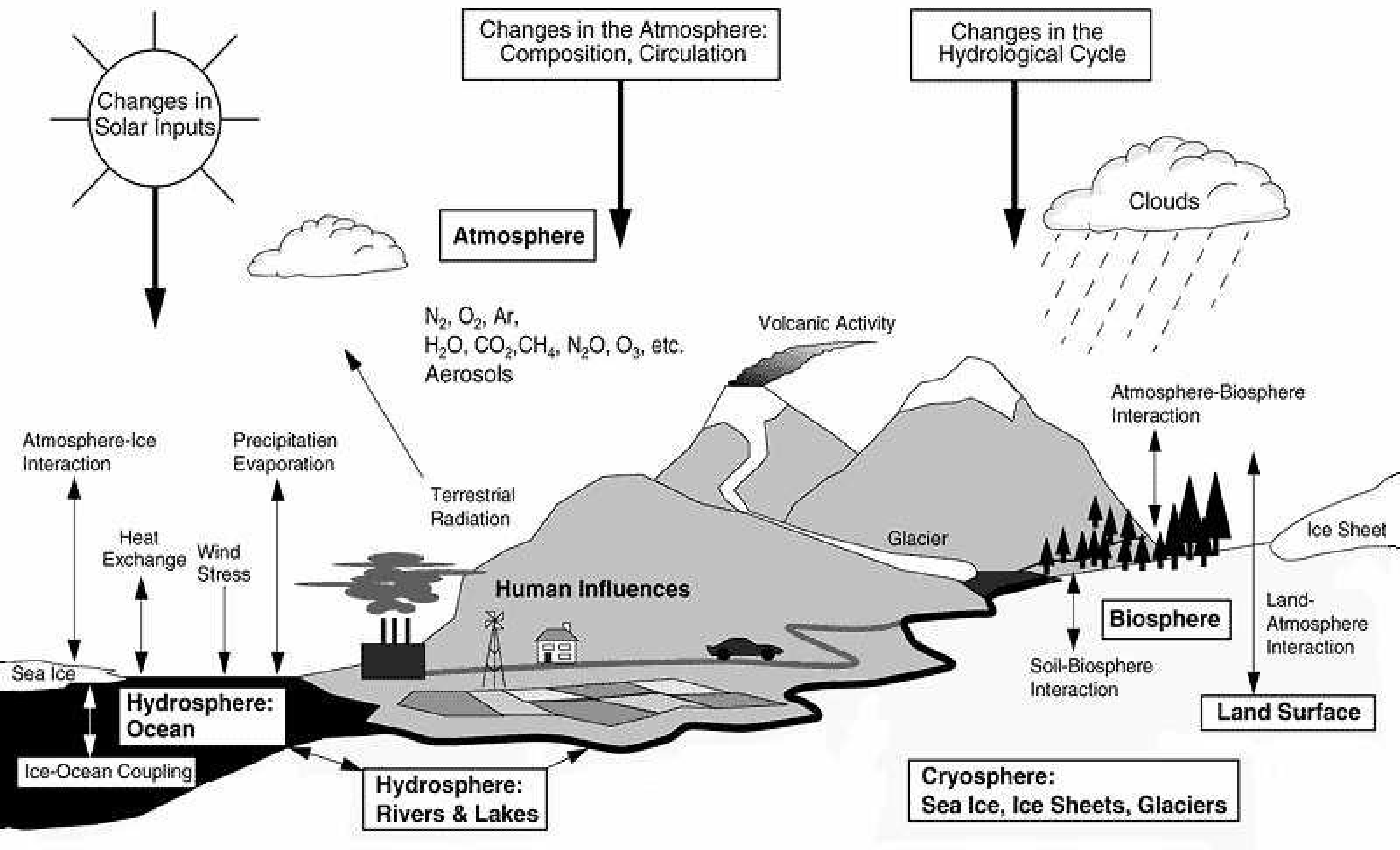
-Many systems in the environment are complicated due to nonlinear interactions of several different components taking place on a vast range of time-space scales.

- Such systems evolve under the action of macroscopic driving (typically the solar heating) and modulating (e.g. the Earth's rotation and gravitation) agents.

-The most comprehensive example is the entire climatic system.

-In its most rigorous definition, the climatic system is constituted by four intimately interconnected sub-systems: atmosphere, hydrosphere, cryosphere, and biosphere

- These subsystems are by themselves complicated and complex and interact nonlinearly with each other on various time-space scales.



Components of the climatic system; the main interactions are also indicated. From IPCC 2001.

1.2. Global environmental issues and challenges

- Environmental issues that have global significance and need to be addressed through international effort. Some of these issues threatening the very future of the planet include:
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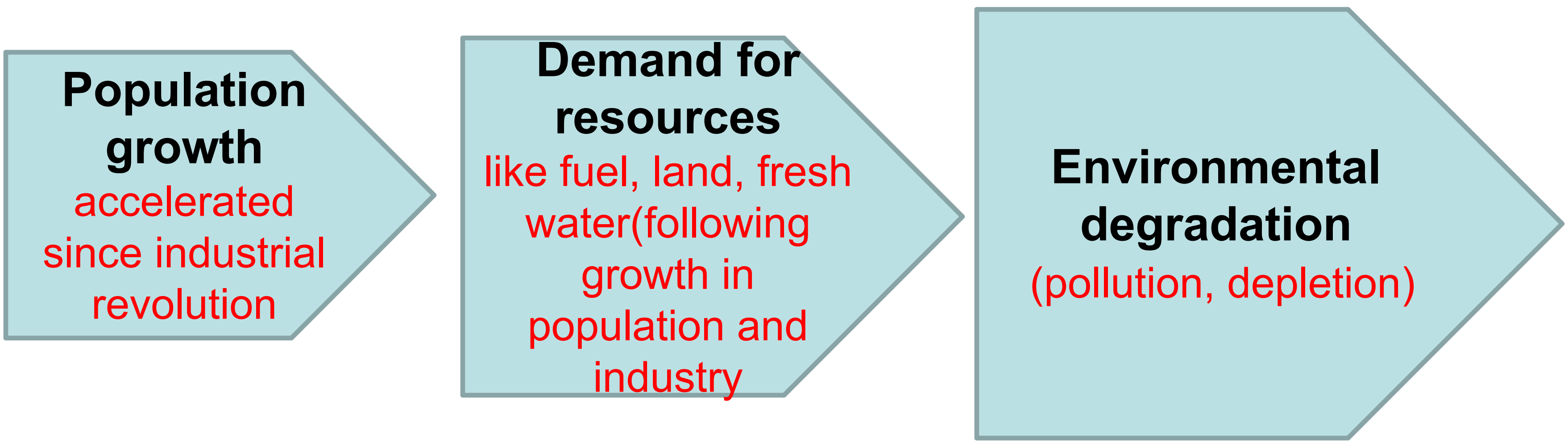


Some environmental issues and problems

A. Population Growth
B. Global Warming
C. Depletion of the Ozone Layer
D. Habitat Destruction and Species Extinction
E. Air Pollution
F. Water Pollution
G. Soil Pollution
H. Groundwater Depletion and Contamination
I. Chemical Risks
J. Environmental Racism
K. Energy Production
L. Natural Hazards

1.3. Managing Resources; sustainability

- Human existence requires the use of basic resources (water, soil, minerals, oil, coal) which must be managed to ensure sufficient future supply and minimal environmental degradation during exploitation

Our current lifestyles are supported by the use of natural resources.

• Basic resources such as water and soil vary in availability and quality around the globe.

• These essential renewable resources are vital to food production and have to be managed to support future population.

Non-renewable resources such as, *metallic minerals & fossil fuels* are used most heavily in the developed and developing countries.

–The use of such resources generates waste during extraction, manufacturing, marketing and consumption.

–This can lead to pollution and to problems with waste disposal.

–These must be managed to ensure sufficient future supply with minimal environmental degradation during exploitation.

Environmental Impact Assessment (EIA)

-EIA as a process of identifying the likely consequences of particular activity on the biogeophysical environment and conveying the result to those responsible.

- EIA is not ***aimed*** to force decision makers to adopt the least environmentally damaging alternative

- but at seeking the ***balance*** between the often competing demands of development and environmental protection

- social and economic factors may be far more pressing than caring for the environment

-In the past: decision makers concern was economic benefits to exceed the cost (cost benefit analysis as basis for project appraisal)

1.4: Population and The Environment

Population, term referring to the total human inhabitants of a specified area, such as a city, country, or continent, at a given time.

-Population study as a discipline is known as ***demography***.

-It is concerned with the size, composition, and distribution of populations; their patterns of change over time through births, deaths, and migration; and the determinants and consequences of such changes.

- Population studies yield knowledge important for planning, particularly by governments, in fields such as health, education, housing, social security, employment, and environmental preservation.

- Such studies also provide information needed to formulate government population policies, which seek to modify demographic trends in order to achieve economic and social objectives

The link between population growth and environmental impact seems obvious at first glance:

more people consume more resources, **damage more** of the earth's natural setting and generate **more waste**.

Human being are **dynamic force** of nature on both renewable and non-renewable resources bringing irreversible damage to the environment.

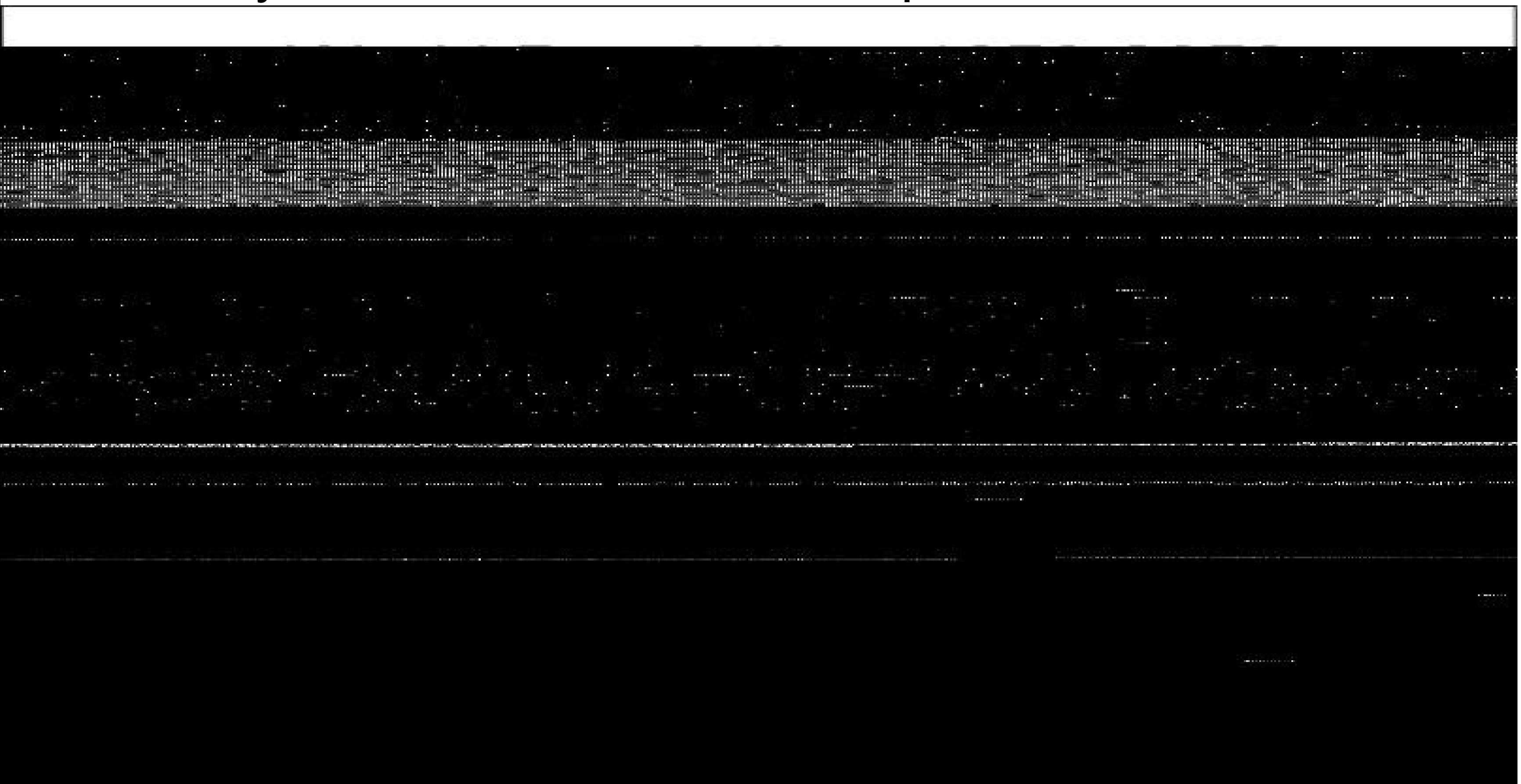
More people are using more resources with **more intensity** than at any point in **human history**.

Fresh water, cropland, forests, fisheries and biodiversity all show signs of **stress** at local, regional and global levels

Human Population Growth

To understand and deal with the environmental problem, we need to know how fast population is growing:

The world population is projected to grow from 6 billion in 1999 to 9 billion by 2042, an increase of 50 percent *according to US Census bureau*



Population trends of the world from the recent past with projection to 2050.

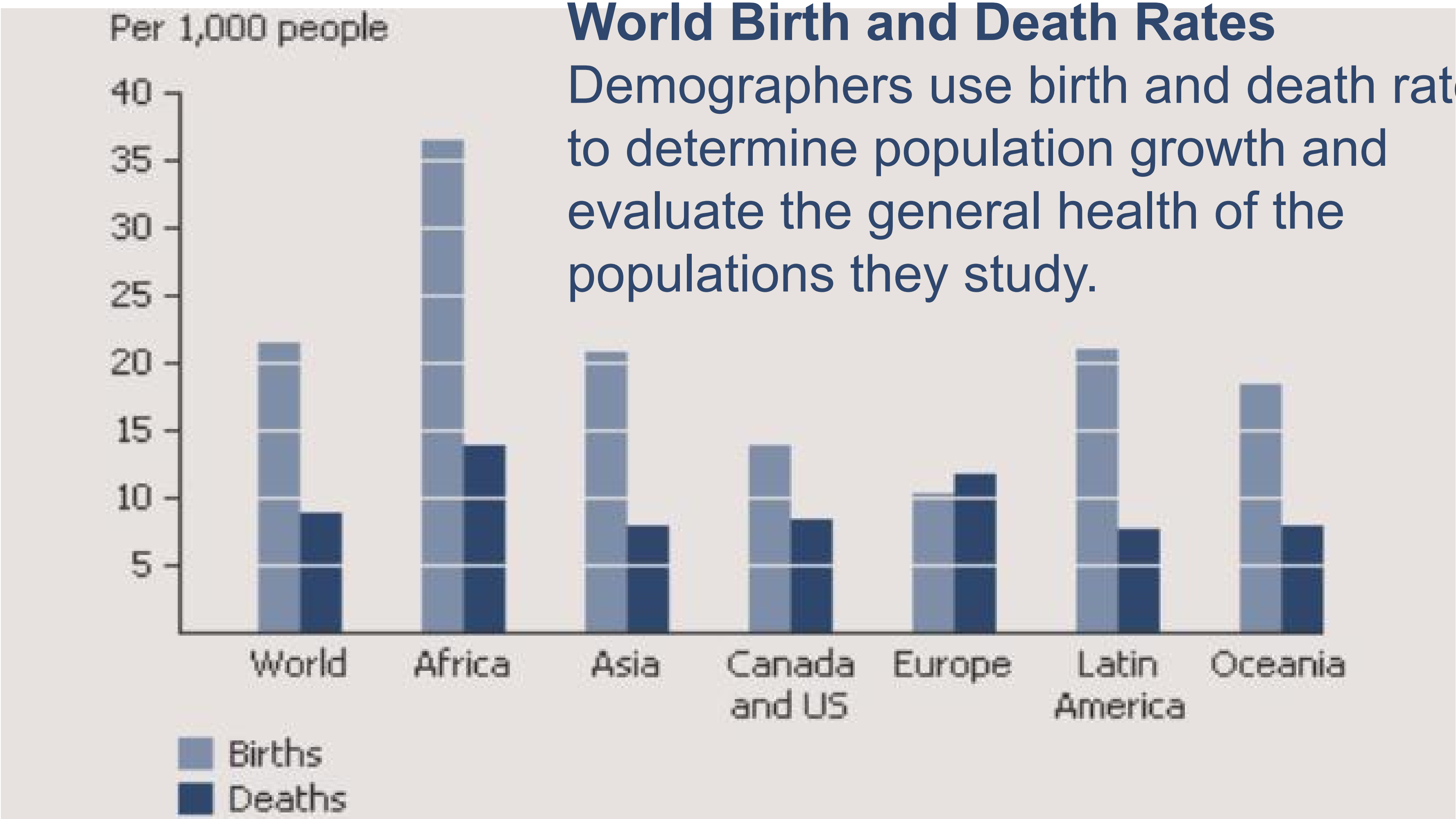
-The world population **growth rate** rose from about 1.5 percent per year from 1950-51 to a peak of over 2 percent in the early 1960s due to reductions in mortality

- Growth rates thereafter started to decline due to *rising age at marriage and increasing availability & use of effective contraceptive methods.*

- A dip in the growth rate from 1959-1960 was due to the Great Leap Forward in China when both natural disasters and decreased agricultural output caused China's death rate to rise sharply and its fertility rate to fall by almost half.

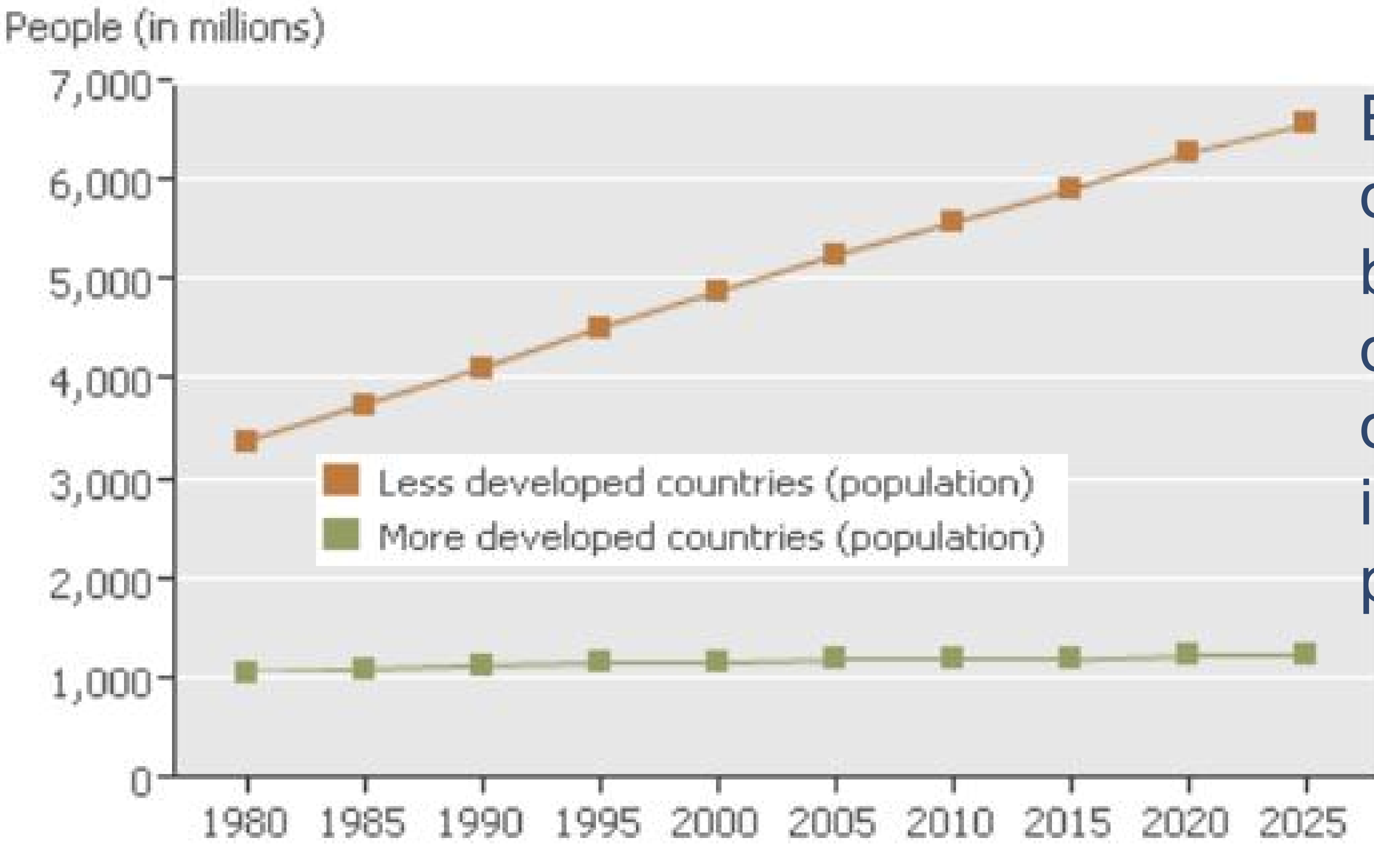
World Birth and Death Rates

Demographers use birth and death rates to determine population growth and evaluate the general health of the populations they study.



These rates usually denote the number of births and deaths per 1,000 people in a given year. This chart shows the estimated birth and death rates for different parts of the world in 2001.

Population Distribution



Economists often distinguish between developed and developing nations in analyzing world population trends.

Generally, nations considered to be developing have a lower standard of living than developed nations. A larger share of the population in these countries live at ***subsistence levels****, and medical resources are limited. As demonstrated by this graph, population growth in less developed nations occurs at a much faster rate than in developed nations.*

Urban concentrations

-As a country develops from *primarily an agricultural to an industrial economy*, large-scale *migration* of rural residents to towns and cities takes place.

- During this process, the growth rate of urban areas is typically double the pace of overall population increase.
- Some 29 percent of the world population was living in urban areas in 1950; this figure was 43 percent in 1990, and is projected to rise to 50 percent by the year 2005.
- Urbanization eventually leads to a severe decline in the number of people living in the countryside, with negative population growth rates in rural areas.

- Dealing with these conditions, especially in very large cities, presents massive difficulties for the governments of less-developed countries.

Slum in Rio de Janeiro

Although Rio de Janeiro occupies a setting of magnificent natural beauty, poverty and urban sprawl have spawned the *favelas*, densely crowded neighborhoods of flimsy shacks. In contrast to the more affluent neighborhoods along the city's southern beaches, favelas cover many of the city's northern hills.

Slum settlement, Mumbai, India

- Human population growth is at the root of virtually all of the world’s environmental problems.
- Although the growth rate of the world’s population has slowed slightly since the 1990s, the world’s population increases by about **77 million** human beings each year. As the number of people increases, crowding generates pollution, destroys more habitats, and uses up additional natural resources.
- Although rates of population increase are now much slower in the developed world than in the developing world, it would be a mistake to assume that population growth is primarily a problem of developing countries.
- In fact, because larger amounts of resources per person are used in developed nations, each individual from the developed world has a much greater environmental impact than does a person from a developing country.
-Conservation strategies that would not significantly alter lifestyles but that would greatly lessen environmental impact are essential in the developed

1.5. Population-resource-environment linkage

a. Human population growth

- Human population growth is nearly impossible to predict, because it is the result of bewildering factors, from advance in agriculture, sanitation, and medicine to the influence of culture, and medical practice.
- The rate of population growth in the last few hundred years is most strikingly accelerated, the pattern can be explained in part by a model known as *exponential growth*.

i.e. the of people increases by a fixed percentage so that both the base amount and the added quantity become larger and larger, even though the rate o increase does not change!

E.g. consider a population of 1 billion people with an annual growth rate of 2 percent. In one year, the population will increase by 2 percent of 1 billion, or 20 million, in the second year, the population will increase by 2 percent of 1 billion plus 20 million (or 20.4 million people)…every year, the number of people added will increase, even though the rate of growth does not change.

- The implications of exponential growth: the suddenness with which a growing population can fill all available space!
- Human population growth double once every 40-46 years at present growth rates

- It took 2 million years of human history to add the first billion people, 130 years to add the second billion, 30 years to add the third, 15 years to add the fourth, and only 12 years to add the fifth.

The consequence of rapid population growth

- The environment will not survive the strain from ever increasing population
- More species of plants and animals will extinct
- More and more of people will die of famine, during droughts or in wars fought over diminishing resources
- *...we will discuss more on these issues in the coming topics*.

- Does the earth have some finite "carrying capacity", some threshold number of people beyond which it can not sustain the human population with clean air, clean water, and adequate nourishment?
- To answer this question, we need to consider not only the number of people but also the quantity of resources necessary for their survival!
- A resource: is anything that we get from our environment that meets our needs and wants. Some resources are directly obtained from the environment (air, water, animal and plant food products) and others are useable after passing through technological processing(oil, iron, minerals).

b. Resources

- Based on their degree of renewability, resources are classified in to 3 as,

1. Potentially renewable
2. Non renewable and
3. Perpetual resources

1. Potentially Renewable resources:

- Can replenish themselves through a natural process, how ever, they can be depleted in the short term if consumed beyond their natural rate of replenishment.

Sustainable yield: the highest rate at which a potentially renewable resource can be used, without decreasing its potential for renewal. If the sustainable yield is excided, the ***base supply*** of the resource will shrink so much that the resource can be exhausted-used up!

- Wind mill, **Ashegoda** Wind Power Project, renewable energy resource

Solar panel

Renewable resources are those which can replace themselves in a life time of a human being!

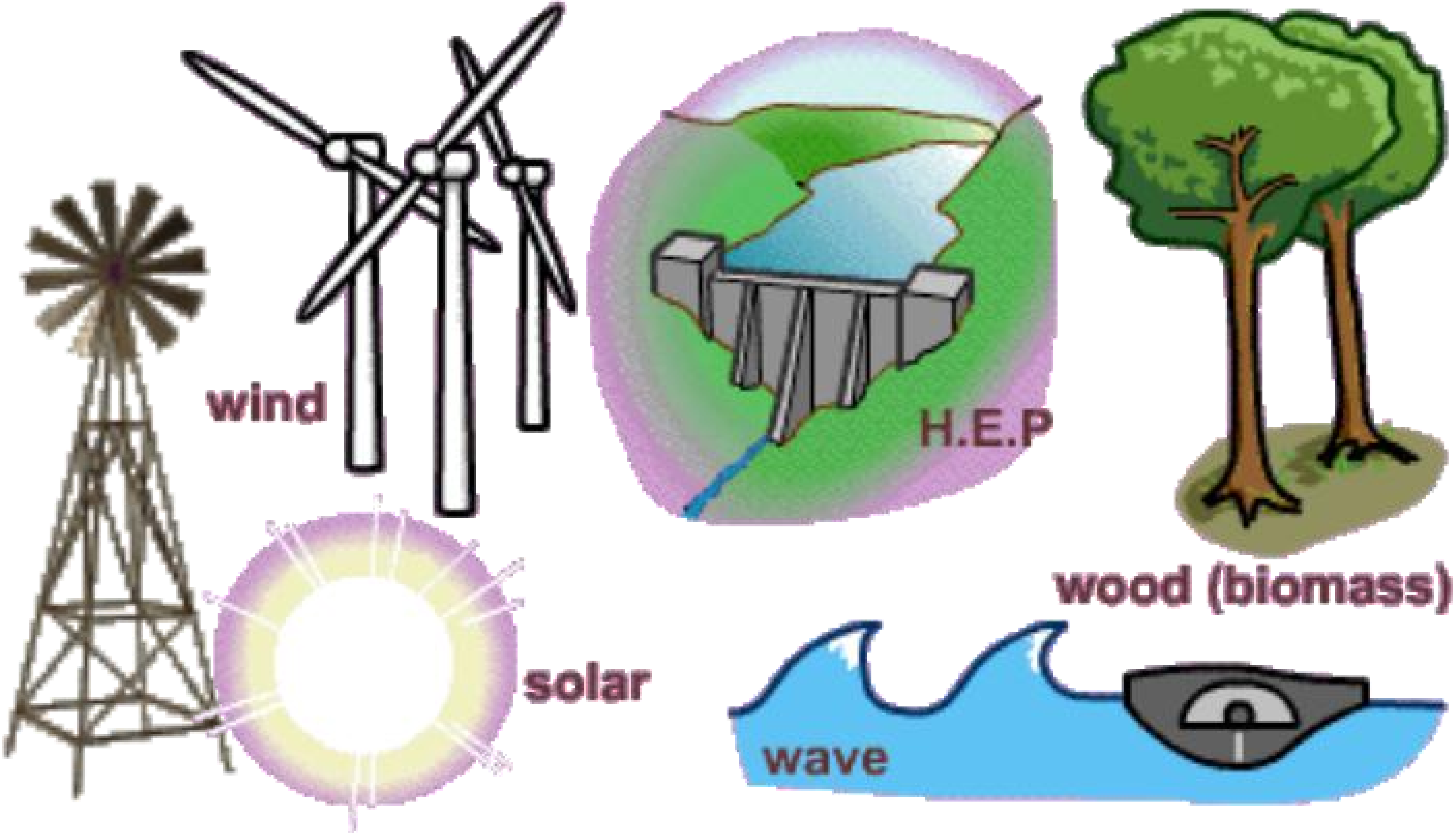
- Example: soil formation: occurs at a rate of 2-3 cm/per thousand years, making it a potentially renewable resource. Unwise farming practices, however, can cause 6-8 cm soil loss per decade.
- Examples of renewable resources: biodiversity resources, water resources.

2. Nonrenewable resources:

Are finite and exhaustible resources, resources that can not replenish themselves in a life time of human beings. These include, fossil fuels and metalic mineral resources.

Some nonrenewable resources like metalic resources can be ***recycled*** or ***reused***.

Figure Examples of renewable resources: biodiversity, water resources



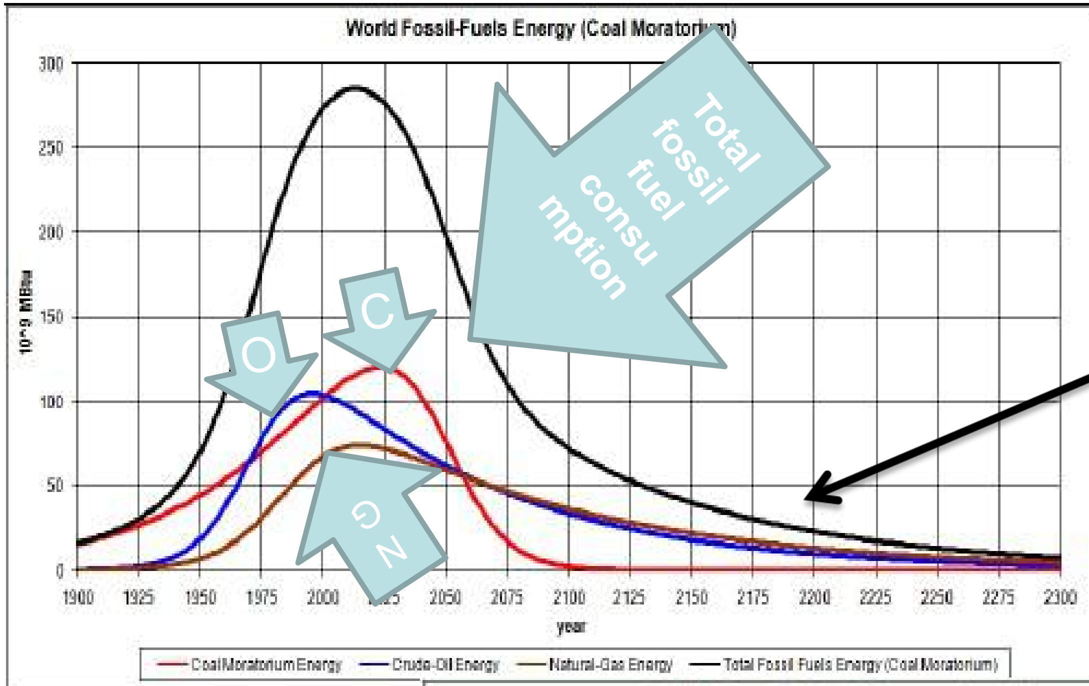
Geyser: geothermal energy in Afar Region, Ethiopia

- **Tekeze** Hydroelectric dam, Ethiopia

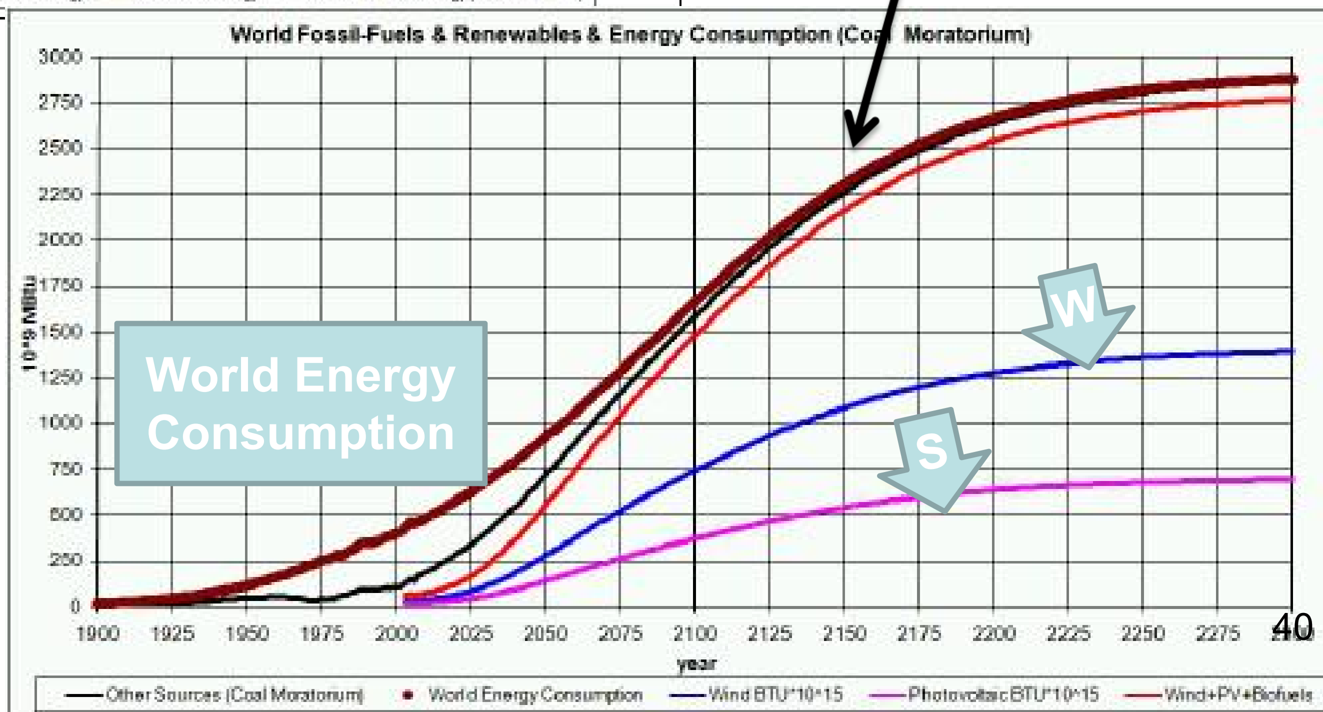
3. Perpetual resources

- Resources which are inexhaustible in human life time scale. Perpetual resources such as solar energy is one that comes from an essentially inexhaustible source and thus will be available in a relatively constant supply regardless of whether or how we use it.
- Examples of perpetual resources: Solar energy, wind energy,
- Production and consumption of renewable, nonrenewable and perpetual resources follow different growth curves

- Potentially renewable resources: similar to the growth rate of biological population.
- Non renewable: Production rises exponentially for some time, reach a maximum value, then decline exponentially as supplies approach zero
- For Perpetual resources such as solar energy, production can rise exponentially for essentially unlimited time periods (human population can relay on fossil fuel energy for quiet limited time).
- Only for Perpetual resources production can increase for ever.



- World fossil fuel consumption follow declining trends and renewable energy consumption follow increasing trends



3. Linkage with Environment

The total environmental impact of population in a given area depends on three factors.

I =PAT

Where **I**: Impact on their environment

P: Population size

A: Demand on the earth's resource per person/Affluence

T: Factor of technology

main shortcoming is that the factors in the equation are related but in complex ways.

however, the approach has been useful in demonstrating that *population dynamics are central to environmental change*

1.6. Earth materials, systems and cycles

- Earth as a system
- Understanding Earth's systems and their changes is critical to solving environmental problems.
- A system is a set of things containing more than one component parts that mutually adjust to function as a whole, with changes in one component brings about changes in other components.
- Example of systems: planet, a volcano, an ocean basin, a river.

Example: The earth as a system

- Components of Earths system:

1. Water(Hydrosphere)
2. Land (Lithosphere)
3. Atmosphere
4. Life (Biosphere)
5. Ice(Cryosphere)

- The components mutually adjust, helping the entire Earth System operating.

How Earths system components work?

- This is a big question, and it would take many books to explain, but think about this example.
- We know weather happens in the atmosphere, but without the hydrosphere, there would be no water to evaporate and so no cloud or rain could form.
- Without oceans and land (hydrosphere and geosphere), there would be no wind (as winds are produced by differences of air temperature between the land and oceans).
- Without the atmosphere (giving us air to breathe and protection from incoming solar rays), there would be no life on Earth.
- It would be as barren as the moon. Without water, life as we know it would cease to exist.
- Last of all, without the geosphere, there would be no world to live on!

- Look at the changing landscape of Earth. Rivers erode the geosphere, changing the physical environment so that plants and animals have to adapt or die.

- Bad weather might increase the weathering of rocks (the way rocks are broken down) changing both the physical and chemical makeup of the rocks.

- These are a few examples to show how the systems are interlinked. Upsetting one system can lead to serious consequences in the sustainability of another system.

- What sphere interactions can you infer from this photograph? To identify sphere interactions, think of one feature in the image at a time, decide which sphere it is a part of, then consider how it interacts with the other spheres.
- With a partner, practice describing interactions in this scene, tracing the movement of materials or energy through all four/five of Earth's spheres if possible. Check your understanding by reading the example interactions below.
- Plants (biosphere) draw water (hydrosphere) and nutrients from the soil (geosphere) and release water vapor into the atmosphere. Humans (biosphere) use farm machinery (manufactured from geosphere materials) to plow the fields, and the atmosphere brings precipitation (hydrosphere) to water the plants. Energy from the sun is stored by plants (biosphere). When humans or animals (biosphere) eat the plants, they acquire the energy originally captured by the plants. Humans expend some of this energy arranging bricks and wood (geosphere and biosphere) into buildings.

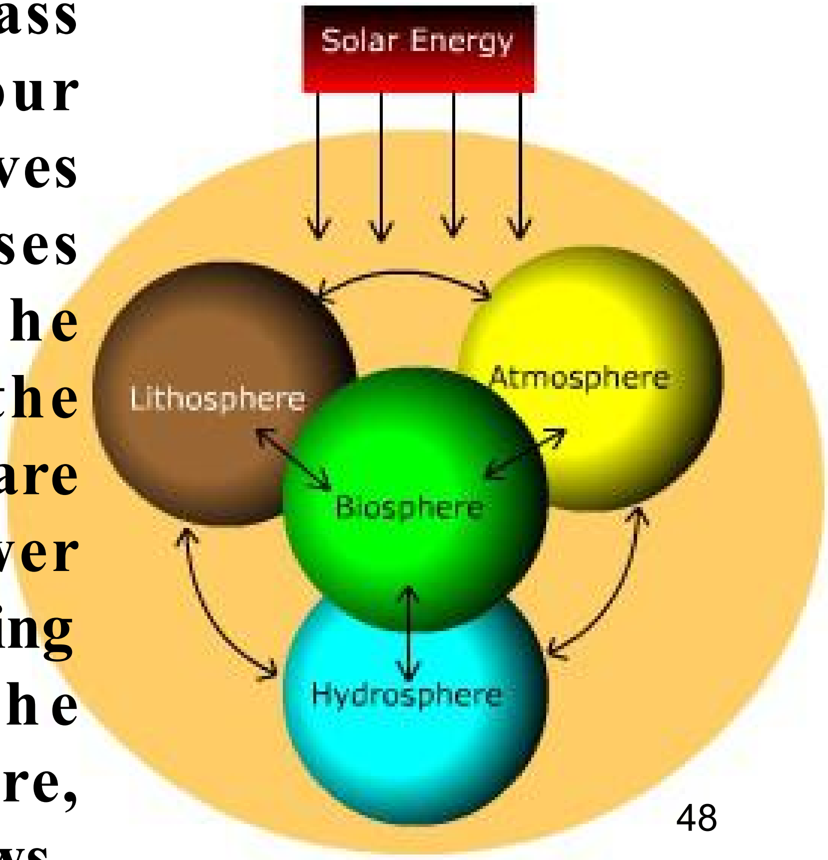
Open systems Vs Closed systems

- Systems can be classified as **open**, **closed**, or **isolated**.
- **Open systems** allow energy and mass to pass across the system boundary.
- A **closed system** allows energy but not mass across its system boundary.
- An **isolated** system allows neither mass or energy to pass across the system boundary.

- The Earth system as a whole is a closed system. The boundary of the Earth system is the outer edge of the atmosphere. Virtually no mass is exchanged between the Earth system and the rest of the universe (except for an occasional meteorite).

- However, energy in the form of solar radiation passes from the Sun, through the atmosphere to the surface. The Earth in turn emits radiation back out to space across the system boundary. Hence, energy passes across the Earth's system boundary, but not mass, making it a closed system.

The Earth system diagram shows arrows representing flows of energy and mass that connect and intertwine the four spheres. At the top, solar energy drives many of the environmental processes operating in the four spheres. The Earth's internal heat engine and the gravitational attraction of the moon are additional sources of energy to power Earth systems. There is a constant cycling of energy and mass between the hydrosphere, lithosphere, atmosphere, and biosphere as indicated by the arrows.



Chapter 2 (3hr)
Interior of the Earth: Earthquakes & Their Effects

Chapter content

2.1. Internal structure and composition of the earth

2.2. Origin and distribution of earthquakes, tsunamis

2.3 Measurement of earthquakes, earthquake magnitude, Earthquake Intensity

2.4 Effects of Earthquakes, Predicting earthquakes and earthquake risks

2.5 The response to earthquake hazards, mitigation measures

2.6. Earthquake hazard in Ethiopia

2.1. Internal Structure and composition of the earth

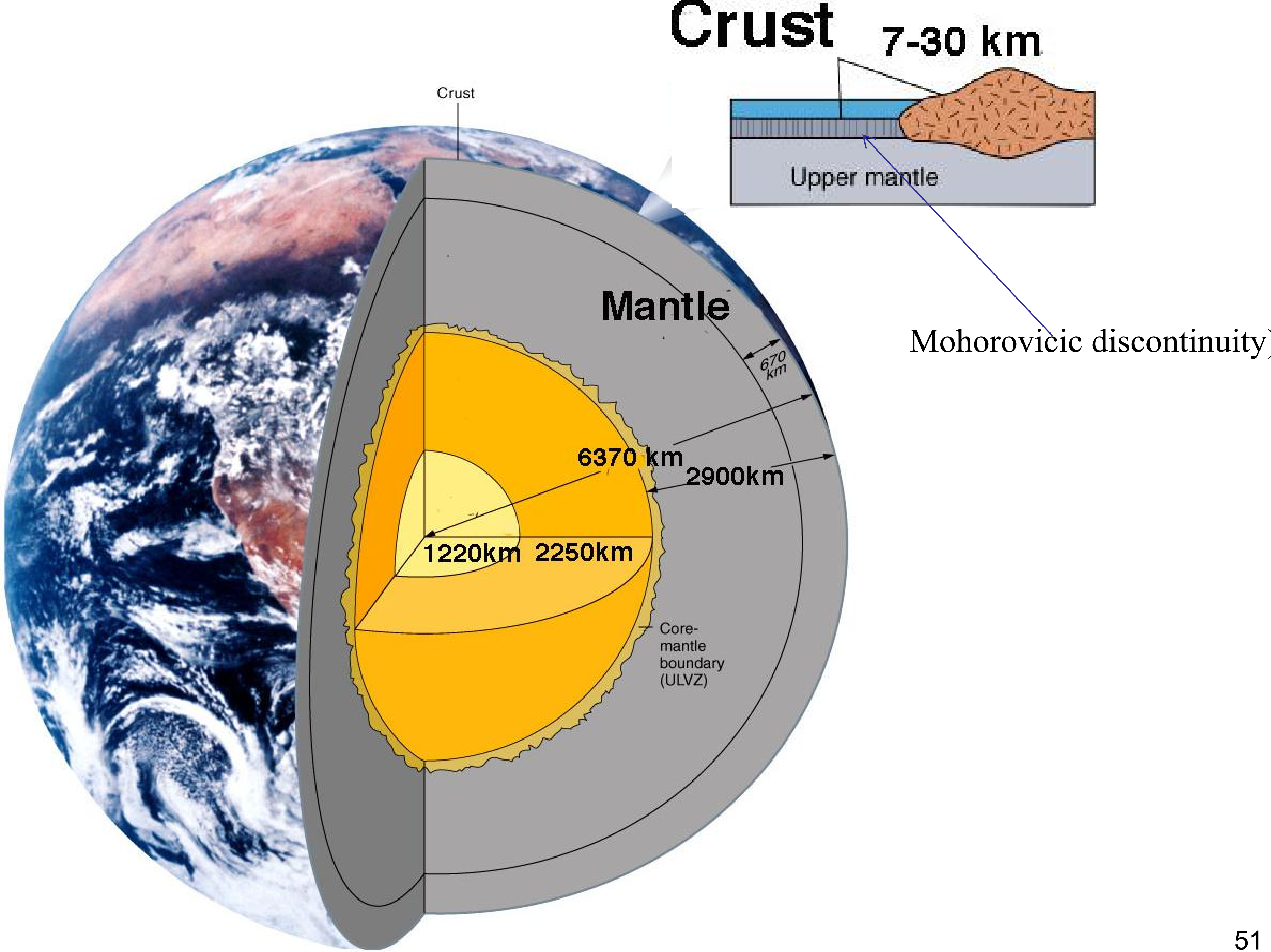
- Earth is a differentiated planet, according to density. It is layered like an onion.
- The evidence (that the earth is layered) comes largely from the studies of the physical properties of the planet itself, density, the way it transmits seismic waves, the nature of its magnetic fields and from comparison with meteorites.
- Based on the these properties, the internal layering of the Earth are recognized according to:

composition as:

- crust
- mantle
- core

physical properties as:

- lithosphere
- asthenosphere
- mesosphere
- outer core
- inner core



Internal structure and composition of the earth

Internal layering based on Composition

The Crust

- it is the outermost layer extending from the solid surface down to the first major discontinuity (the Mohorovicic discontinuity) of the lithosphere
- its density ranges from 2.7 (continental crust) to 3.2 (oceanic crust)
- made up of light weight materials (silicate rocks)
- of two types; continental and oceanic crust

i. continental crust:

- is thicker: as much as 70 km
- composed, generally, of light weight rocks such as granite
- includes the oldest rocks of the crust
- average density of 2.7 gram per centimeter cube

ii. oceanic crust

- is thinner, about 8 km thick
- is dark, dense volcanic rock(basalt)
- younger and relatively un deformed
- average density is 3.0 g/cm3

The Mantle

- covers the core
- constitute the major(great) bulk of the Earth making up 82% of the volume and 68% of the mass of the Earth
- it is largely composed of magnesium and iron silicates
- it extends from 50km to 2900 km in to the inner Earth
- its density ranges from 3.4 to 5.5g/cm3

The Core

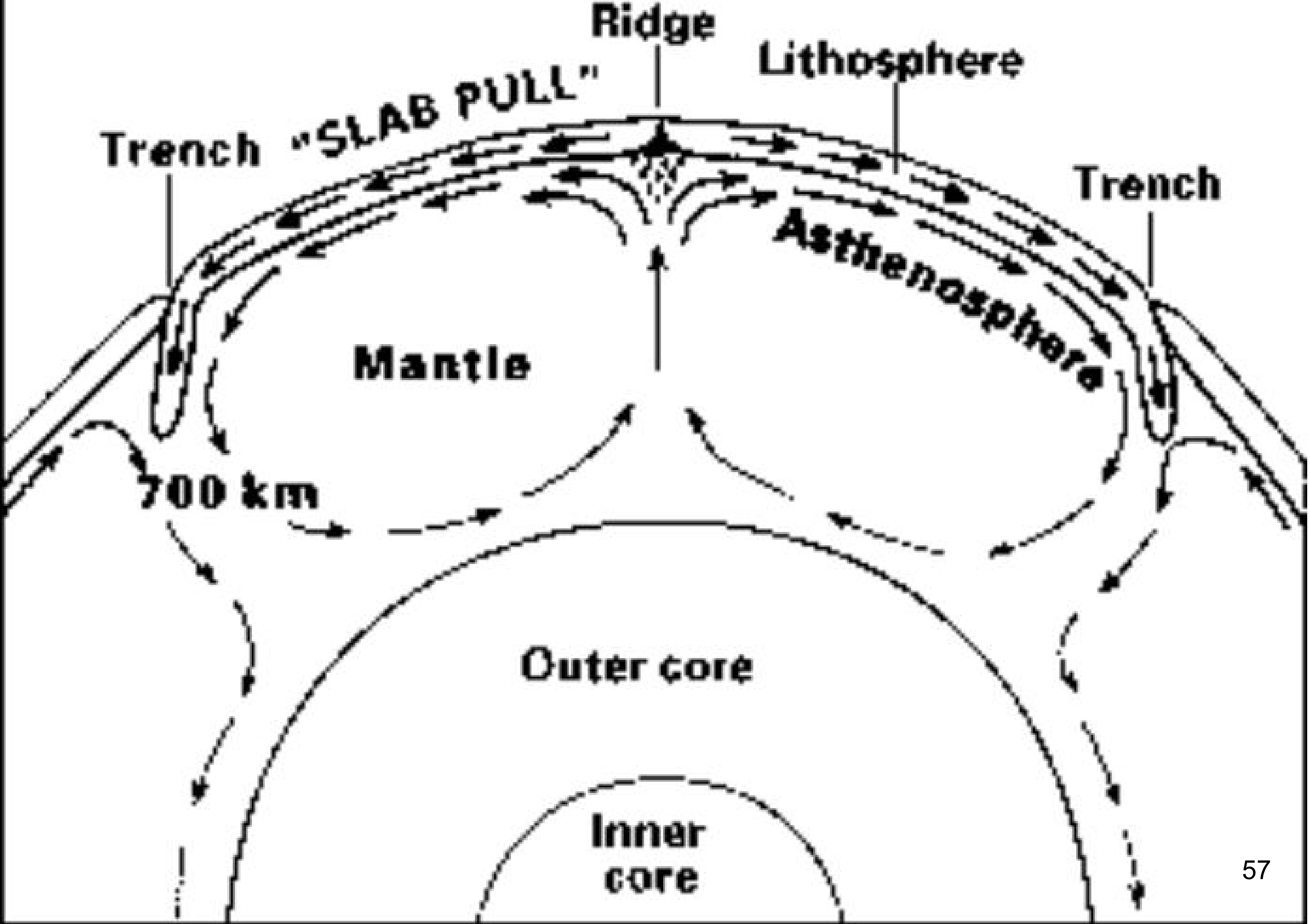
- is the central mass extending from 2900km up to the center, 6400km(7,000km in diameter)
- mostly made of iron with some nickel
- average density is 10.79 g/cm3
- constitute 16% by volume and 32% by mass of the Earth

Internal Layering Based on Physical Properties

1. **Lithosphere:** this is the solid, strong and rigid outer part of the Earth that contains the crust and the upper most part of the mantle. It extends 100 km from the surface.
2. **Asthenosphere** "Weak sphere"). **:** There is a major zone within the upper mantle where temperature and pressure are at just the right balance so that part of the material melts. The rocks lose much of their strength and become soft plastic and flow like warm tar. It is a distinctive zone in the upper mantle and is as much as 100km thick-very important zone from the point of view of earthquakes and plate movements.

3. **Mesosphere:** this zone is stronger and much rigid than the asthenosphere because the high pressure at this depth offsets the effect of high temperature. This is the region b/n the asthenosphere and the core.

4. **The Core:** it marks both a change in physical property and composition. On the basis of physical properties the core is divided into the outer and inner core, in which the outer core is liquid while the inner core is solid. Heat lose from the core and the rotation of Earth probably causes the liquid outer core to circulate and its circulation generates Earth's magnetic field.


Ridge
Lithosphere
"SLAB PULL"
Trench
Trench
Asthenosphere
Mantle
700 km
Outer core
Inner core

Composition of the earth

1. *The major elements* - those which are present in large quantities in the Earth's crust. They constitute the rock forming minerals. There are eight elements in this group and they are so common that they make up 99% of the weight of the Earth's crust.

1. O 47%
2. Si 28%
3. Al 8%
4. Fe 5%
5. Ca 3.5%
6. Na 3%
7. K 2.5%
8. Mg 2%
9. Others 1%

2. *The minor elements* - those which are much less common in the Earth's crust. They are rare, they amount in total 1% by weight of the crust. However this group contains elements vital for industry.

E.g. Copper (Cu) 0.007%

Uranium (U) 0.0004%

Gold (Au) 0.000 0005%

*By far the greatest percentage of the crust is made up of silicon and oxygen. These two elements readily combine with each other, and with other elements to form the commonest mineral group on earth: silicate minerals. Silicates make up over 98% (by weight) of the crustal rocks.

2.2 Origin and distribution of earthquakes, tsunamis

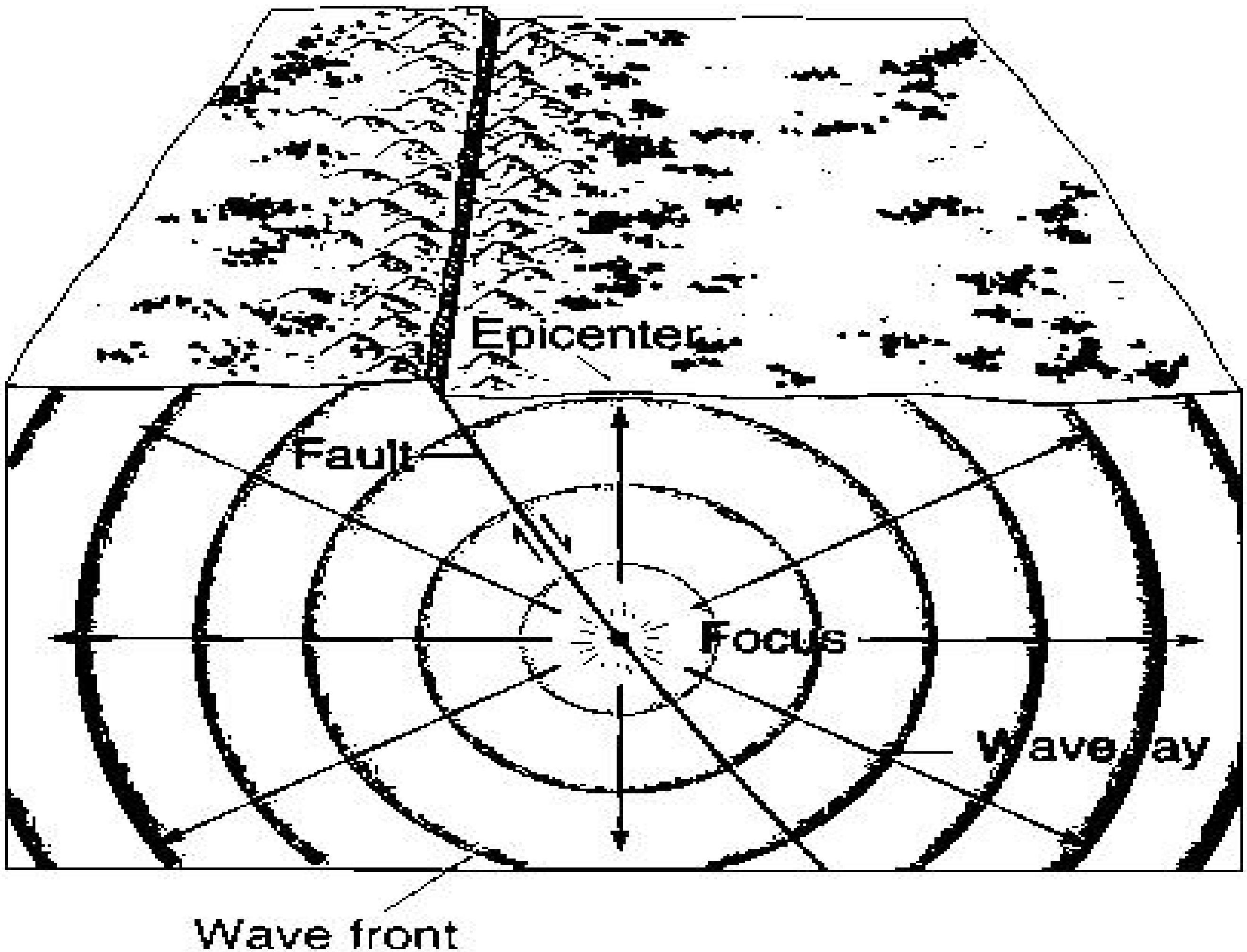
- Definition: Earthquake is a movement within the earths crust or mantle, caused by the sudden rupture or repositioning of underground rocks as they release stress.

- Earthquakes occur when energy stored in elastically strained rocks is suddenly released.
- This release of energy causes intense ground shaking in the area near the source of the earthquake and sends waves of elastic energy, called seismic waves through out the Earth.

Origin of Earthquakes

- Most natural earthquakes are caused by sudden slippage along a fault zone.
- The elastic rebound theory suggests that if slippage along a fault is hindered such that elastic strain energy builds up in the deforming rocks on either side of the fault, when the slippage does occur, the energy released causes an earthquake.

Seismic wave fronts and wave rays

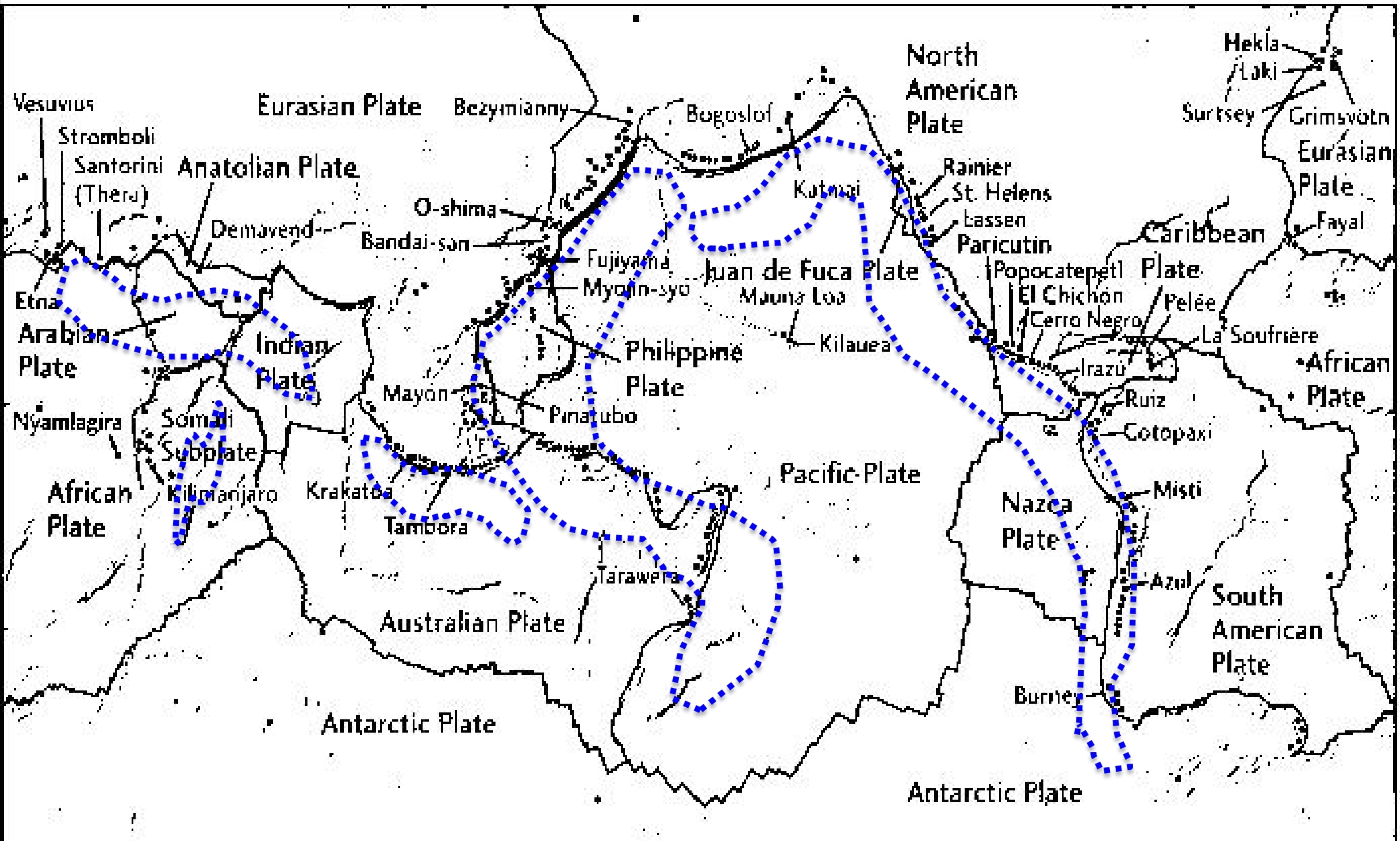


Distribution of earthquakes, tsunamis

- Earthquakes can occur anywhere on earth, but they are concentrated in two major belts

1. The circum- pacific Belt (80 percent) and
2. The Mediterranean-Trans-Asiatic Zone (15 percent)

- These belts coincide generally with zones of active volcanism and plate boundaries


Vesuvius
Stromboli
Santorini (Thera)
Anatolian Plate
Eurasian Plate
Bezymianny
Bogoslof
North American Plate
Hekla
Laki
Surtsey
Grimsvotn
Eurasian Plate
Demavend
O-shima
Bandai-san
Katmai
Rainier
St. Helens
Lassen
Paricutin
Fayal
Caribbean Plate
Etna
Fujiyama
Myojin-syo
Juan de Fuca Plate
Mauna Loa
Popocatepetl
El Chichon
Cerro Negro
Pelée
La Soufrière
Arabian Plate
Indian Plate
Kilauea
Philippine Plate
Irazu
African Plate
Mayon
Pinatubo
Ruiz
Nyamlagira
Somali Subplate
Cotopaxi
African Plate
Kilimanjaro
Krakatoa
Tambora
Pacific Plate
Nazca Plate
Misti
Tarawera
Azul
South American Plate
Australian Plate
Burney
Antarctic Plate
Antarctic Plate

Measurement of earthquakes: magnitude and Intensity

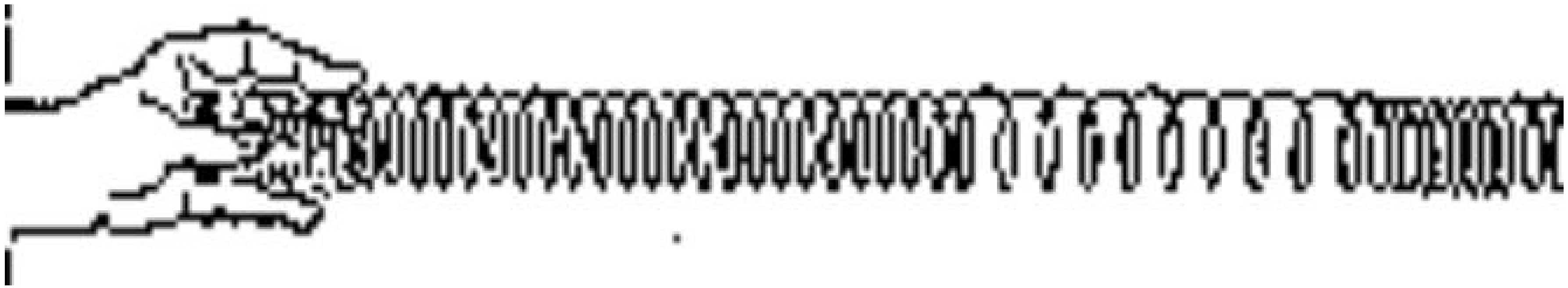
Earthquake Waves

- The seismic waves radiate in all directions from the focus. The initial waves travel through the interior of the earth and are called body waves.
- When the energy reaches the surface, surface waves are generated
- Body waves: two types

1. P-waves
2. S-waves

P –waves: called primary waves

- Formed by the alternate contraction and expansion of bedrock, push and pool motion. Also called longitudinal wave
- Travel faster than S-waves, reach the seismogram station first.
- Travel at a speed of 5-7 Km/s in the Lithosphere.
- Can travel through solids, liquids and gases.



Secondary waves

- S-wave is transverse, which means that particles in the waves path move from side to side or up and down at right angles to the wave's advance
- Travels much slower than the P wave and is the second signal to arrive at a recording station
- S-waves advance by shearing displacements , displacements that change shape without changing volume

Surface waves

- Surface waves differ from body waves in that they do not travel through the Earth, but instead travel along paths nearly parallel to the surface of the Earth.
- Surface waves behave like S-waves in that they cause up and down and side to side movement as they pass.
- but they travel slower than S-waves and do not travel through the body of the Earth .
- Surface waves are of much greater length and period and transmit a large proportion of earthquake energy
- They are largely responsible for damage to surface structures.

Measurement of earthquakes: magnitude and Intensity

Magnitude of Earthquakes

- The size of an earthquake is usually given in terms of a scale called the Richter scale.
- The Richter Magnitude involves measuring the amplitude (height) of the largest recorded wave at a specific distance from the earthquake
- A better measure of the size of an earthquake is the amount of energy released by the earthquake. While this is much more difficult to determine, it can be estimated:

$$\text{Log } E = 11.8 + 1.5\, M,$$

- Where E is the energy released and M is the Richter Magnitude.

Earthquake Intensity: **Modified Mercalli Intensity Scale**

- the Richter magnitude scale results in one number for the size of the earthquake.
- Maximum ground shaking will occur only in the area of the epicenter of the earthquake,
- but the earthquake may be felt over a much larger area. The Modified Mercalli Scale was developed to assess the intensity of ground shaking and building damage over large areas
- The scale is applied after the earthquake by conducting surveys of people's response to the intensity of ground shaking and destruction

Earthq rquency?

Frequency of Occurrence of Earthquakes Based on Observations since 1900 (**http://wwwneic.cr.usgs.gov/neis/eqlists/eqstats.html**)

Descriptor	**Magnitude**	**Average Annually**
Great	8 and higher	1
Major	7 - 7.9	18
Strong	6 - 6.9	120
Moderate	5 - 5.9	800
Light	4 - 4.9	6,200 (estimated)
Minor	3 - 3.9	49,000 (estimated)
Very Minor	< 3.0	**Magnitude 2 - 3: about 1,000 per day** **Magnitude 1 - 2: about 8,000 per day**

2.4 Effects of Earthquakes, Predicting earthquakes and earthquake risks

Effects of Earthquakes

- The risk that an earthquake will occur close to where you live depends on whether or not tectonic activity that causes deformation is occurring within the crust of that area
- The risk is greatest in the most tectonically active area i.e. near the plate margin
- The impact of an earthquake is determined by the following factors

1. Amount of energy released
2. Frequency orientation and duration of shaking
3. Distance from epicenter
4. Physical properties of bedrock and sacrificial materials and
5. Building design.

Topographic Effects

- up warping or subsidence
- offset along faults, and ground cracking
- Shaking of the ground
- landslides or soil liquefaction (Liquefaction is a process which transforms material which behaves as a solid in to material which behaves as a liquid)
- In mountainous regions : ground shaking may trigger rapid mass-wasting events rock and debris falls,
- rock and debris slides
- slumps, and
- debris avalanches.

- **Earthquake Risks**

“earthquakes don't kill people, buildings do”.

✓ This is because most deaths from earthquakes are caused by buildings or other human construction falling down during an earthquake.

✓ Earthquakes located in isolated areas far from human population rarely cause any deaths

- Thus, earthquake hazard risk depends on

1. Population density,
2. construction standards (building codes) and
3. Emergency preparedness

EARTHQUAKE PREDICTION AND CONTROL

Long-Term Forecasting- is based mainly on:

- ✓ The knowledge of when and where earthquakes have occurred in the past.
- ✓ Knowledge of present tectonic setting,
- ✓ Historical records, and geological records,

to determine locations and recurrence intervals of earthquakes.

- ❑ Two aspects of this are important. I.e.. For the long term prediction

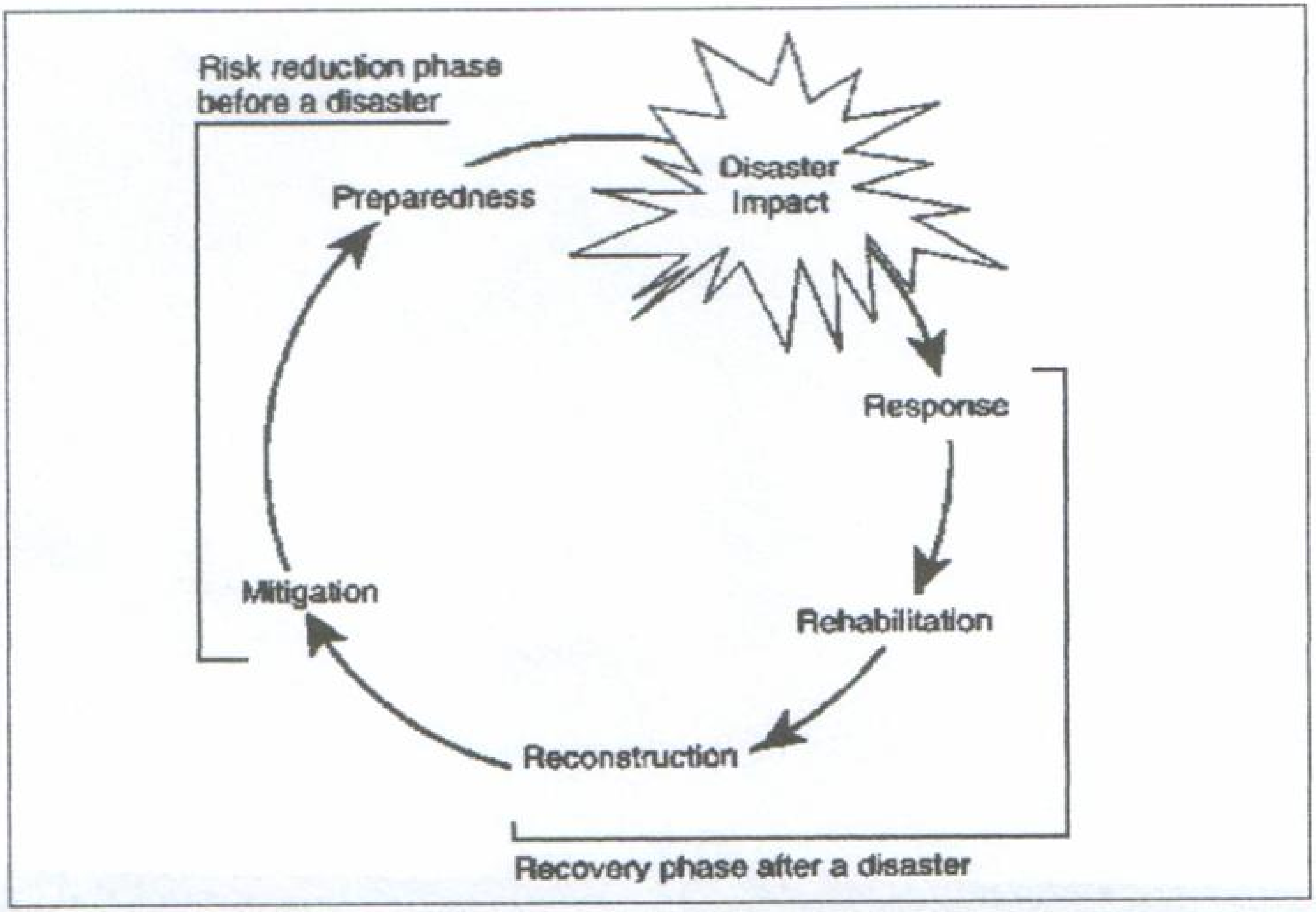
1. **Paleoseismology** - the study of prehistoric earthquakes through study of the offsets in sedimentary layers near fault zones in which it is often possible to determine recurrence intervals of major earthquakes prior to historical records.

2. **Seismic gaps** - is a zone along a tectonically active area where no earthquakes have occurred recently, but it is known that elastic strain is building in the rocks. If a seismic gap can be identified, then it might be an area expected to have a large earthquake in the near future.

2.5 The response to earthquake hazards,

- The response to earthquake hazards and mitigation measures
- **Response to Earthquake Hazards**
  - Hazard Reduction Programs
    - ➢ Develop a better understanding of the source and processes of earthquake
    - ➢ Determine earthquake risk potential
    - ➢ Predict effects of earthquakes
    - ➢ Apply research results

: Management sequence of disasters and emergencies



- Adjustments to earthquake activities
  - Site selection for critical facilities
  - Structure reinforcement and protection
  - Land-use regulation and planning
  - Emergency planning and management: Insurance and relief measures

Mitigation measures…..

- "Mitigation" can be defined as the permanent reduction of the disaster risk and can be categorized as "primary mitigation" which refers to reducing the presence of the hazard and of the vulnerability, and "secondary mitigation", which refers to reducing the impact of the hazard.
- "Preparedness" covers the measures that insure the organized mobilization of personel, funds, equipment and supplies within a safe environment for effective relief, "response" can be defined as the set of activities implemented after the impact of a disaster in order to assess the needs, reduce the suffering, limit the spread and the consequences of the disaster and open the way to rehabilitation.

Earthquake hazard in Ethiopia

Eastern and Southern Africa covers a region which is prone to a significant level of seismic hazard due to the presence of the East African rift system. A number of destructive earthquakes,

- A number of destructive earthquakes, some causing loss of life have been reported in this century
- For example, in Eritrea, the port city of Massewa was destroyed by an earthquake which occurred in 1921.
- In Ethiopia, in 1960, the Awassa earthquake (Ms 6.1) has caused a damage

- In 1961, the karakore earthquake has destroyed completely the town of Majete, and severely damaged the town of Karakore.
- In 1969, the Serdo earthquake (Ms 6.3), 4 people were killed, 24 injured
- The 1989 Dobi graben earthquake (Ms 6.5) has destroyed several bridges along the highway connecting Asseb and Addis Ababa.
- The 1983 Wendo Genet and 1985 Zeway earthquakes caused damage in parts of the Ethiopian rift valley.

Chapter 3:
Natural Hazards: Volcanic Activity and Volcanic Hazards [3 hrs]

- Revision: Volcanism and associated phenomena
- Volcanic hazards
- Forecasting volcanic activity
- Predicting volcanic hazards and mitigation measures
- Volcanic hazards in Ethiopia

Revision

- **Volcanism and associated phenomena**

Definition: Volcanism?

A volcano is "an opening in the Earth's crust through which an eruption takes place"

Volcanoes are eruptions of hot molten lava and ash that rises from deep beneath the earth's crust.

Volcanic eruptions are one of Earth's most dramatic and violent agents of change.

✓ alter land

✓ change our planet's climate temporarily

✓ Force people to abandon their land and homes, sometimes forever

Terminologies

- **Magma** – hot, liquid rock beneath the Earth’s surface.
- **Lava** – hot, liquid rock that reaches (and goes above) the Earth’s surface.
- **Magma chamber:** The subterranean cavity containing the gas-rich liquid magma which feeds a volcano.
- **Conduit:** A passage followed by magma in a volcano.
- **Vent**: The opening at the earth's surface through which volcanic materials issue forth.
- **Cone:** A volcanic cone built entirely of loose fragmented material (pyroclastics) and (or) lava flows erupted from the vent. Erupted material builds up with each eruption forming the cone.

Causes of Volcanic Activity

- origin to subsurface (androgenic) processes
- A volcano builds up around a vent, or series of cylindrical conduits, which connects with reservoirs of molten rock called magma

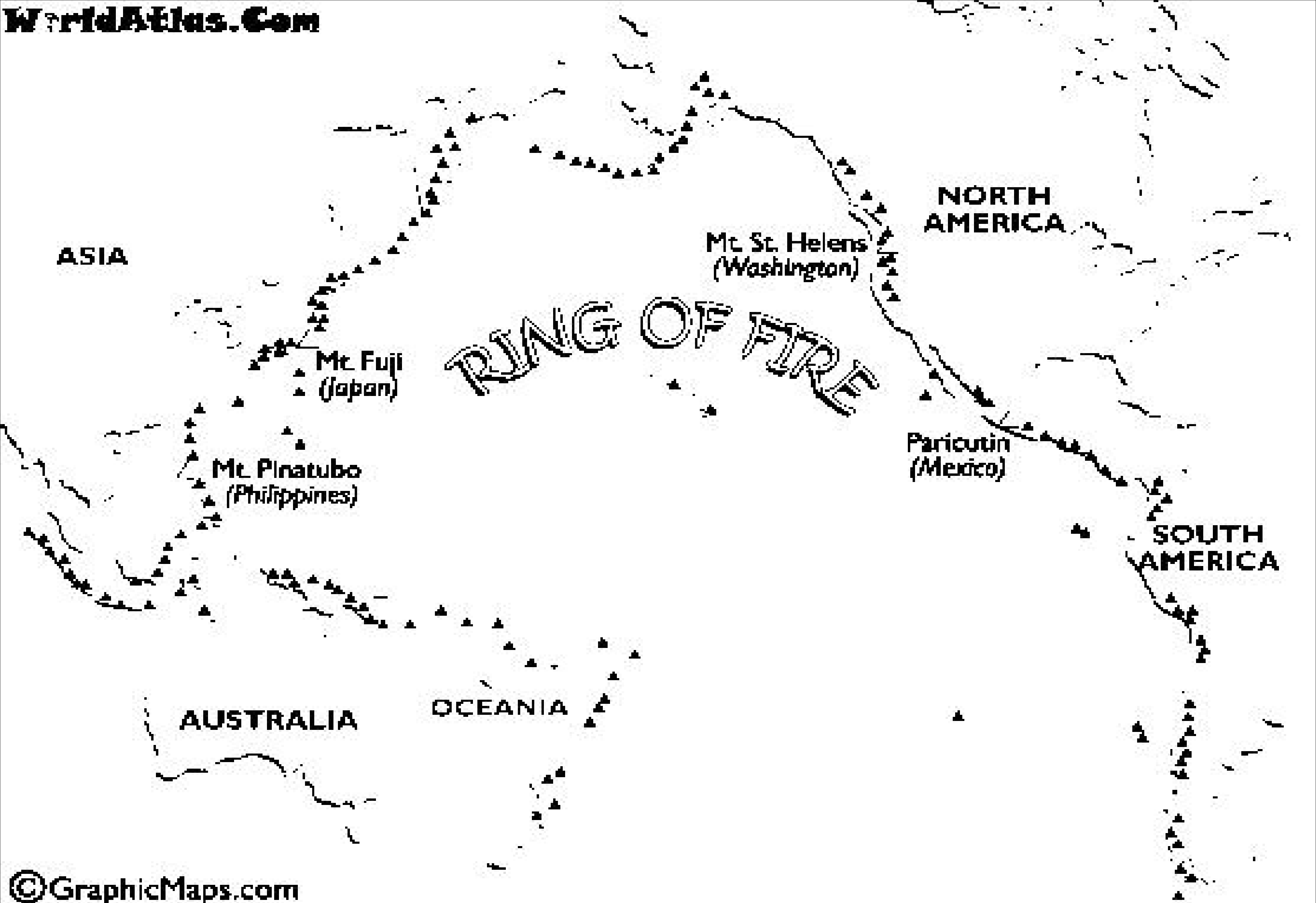
Possible sources of heat below the surface??:

- ➢ Radioactive decay is a breaking apart of the nucleus of an atom; as a nucleus breaks apart, it releases energy which is changed into heat.
- ➢ Original Heat inside the earth may have been trapped when the earth first formed.
- ➢ Friction – results from the movement of lithospheric plates.
- ➢ Fusion in the core – nuclear fusion, similar to the sun, is occurring in the core

How magmas form?

1. Partial melting as the *geothermal gradient* of the Earth increases with depth
2. Along Divergent plate boundaries: *convection currents*
3. Along Convergent plate boundaries: melting/ consumption of *old subducted crust*
4. Hotspots: localized mantle *plums*

- Most modern volcanoes (79 percent) are concentrated in the ‘’ring of fire’’ that circumscribes the Pacific Ocean Basin.



The ring of fires

- **Characteristics of Magma**

Types of Magma

Types of magma are determined by chemical composition of the magma. Three general types are recognized:

1. ***Basaltic magma*** -- SiO_2 45-55 wt%, high in Fe, Mg, Ca, low in K, Na
2. ***Andesitic magma*** -- SiO_2 55-65 wt%, intermediate. in Fe, Mg, Ca, Na, K
3. ***Rhyolitic magma*** -- SiO_2 65-75%, low in Fe, Mg, Ca, high in K, Na

Summary Table					
Magma Type	Solidified Rock	Chemical Composition	Temperature	Viscosity	Gas Content
Basaltic	Basalt	45-55 SiO_2 %, high in Fe, Mg, Ca, low in K, Na	1000 - 1200 oC	Low	Low
Andesitic	Andesite	55-65 SiO_2 %, intermediate in Fe, Mg, Ca, Na, K	800 - 1000 oC	Intermediate	Intermediate
Rhyolitic	Rhyolite	65-75 SiO_2 %, low in Fe, Mg, Ca, high in K, Na.	650 - 800 oC	High	High

Magma composition determines the ***eruptive style*** of the volcano

1. ***Non explosive Eruptions***

- Non explosive eruptions are favored by ***low gas*** content and ***low viscosity*** magmas (***basaltic*** to andesitic magmas).
- ***Lava flows*** are produced on the surface, and these run like liquids down slope,
- If the *viscosity is high, but the gas content is low*, then the lava will pile up over the vent to produce a ***lava dome*** or volcanic dome.

2. Explosive Eruptions

- Explosive eruptions are favored by h***igh gas content and high viscosity*** (andesitic to rhyolitic magmas).
- Explosive bursting of bubbles will fragment the magma into clots of liquid that will cool as they fall through the air.
- These solid particles become ***pyroclasts*** (meaning – hot fragments) and ***tephra or volcanic ash***, which refer to sand- sized or smaller fragments.

Volcanic hazards

- Type of volcanic Hazards

1. Primary hazard
2. Secondary hazard

1. Primary effects

✓ **Lava Flows**

- Most familiar products of volcanic activities
- Most are slower and give people time to move out
- Most damaging to property

Lava Flows

Although not generally as hazardous as explosive eruptions, lava flows can burn and bury buildings and forests and do pose a danger to people living on or near an active volcano

Slowly but surely!

Magma that reaches the earth's surface is called lava. In this picture, red-hot lava flows from a volcano on Réunion, an island off the coast of Africa in the Indian Ocean. The lava wrinkles because the exterior and interior of the flow cool at different rates. The surface of the flow cools relatively quickly, forming a skin that becomes deformed as the hotter lava moves underneath.

✓ **Pyroclastic Activity**

- *Most dangerous* aspects of volcanism
- Cause death by *suffocation and burning*
- They can *travel so rapidly* that few humans can escape
- Tephra falls can cause the collapse of roofs , away from area of eruption
- Destroy vegetation, including crops, and can kill livestock

- Historic example, Pompeii (79AD), Italy
- Pyroclastic flows of poisonous gas and hot volcanic debris engulfed the cities of Pompeii, Herculaneum and Stabiae suffocating the inhabitants and burying the buildings.

- The people and animals of Pompeii died in their sleep or trying to evacuate the town. If you visit Pompeii today you can see their remains…
  - ✓ **Ash load**
    - – Collapses roofs
    - – Brings down power lines
    - – Kills plants
    - – Contaminates water supplies
    - – Respiratory hazard for humans and animals

- Moving on from pyroclastic flows, there are other hazards associated with volcanic eruptions. Such as Pyroclastic Fall:
- An explosive eruption will produce an eruption column of hot gas, ash and debris ejected ***kilometres*** into the air. As this debris falls back down to the ground it can cause a lot of damage.
- Like too much snow **on a roof,** too much ash raining down from an eruption column can cause the roof to collapse.
- Ash loading on ***power lines*** will cause them to fall.
- As little as *1 centimetre* of ash accumulated **on the leaves** of a plant will stop it from being able to photosynthesize and therefore the plant will die.
- Lots of fine ash falling **in lakes, rivers and water reservoir**s will cause contamination making it unfit to drink, or to live in if you are a fish etc.
- Very fine ash particles, if inhaled by humans, can cause extensive damage to the lungs causing a respiratory disease **called silicosis.**

✓ **Poisonous Gas Emissions**

- Hydrogen Chloride (HCl), Hydrogen Sulfide (H2S), Hydrogen Fluoride (HF), and Carbon Dioxide (CO2)
- Toxic chemicals incorporated in to the soil and in to plants, leached in to water supply, and eaten by people and livestock

2. Secondary effects

✓ **Volcanic Mudflows (Lahars)**

- Volcanoes can emit *voluminous quantities of loose*, unconsolidated tephra which become deposited on the landscape.
- Such loose deposits are subject to *rapid removal* if they are exposed to a source of water-rain
- Mudflows are a mixture of *water and sediment*, they move rapidly down slope along existing stream valleys

✓Debris Avalanches and Debris Flows

- Volcanic mountains tend to become over steepened as a result of the addition of new material over time and inflation of the mountain as magma intrudes
- Over steepened slopes may become ***gravitationally unstable***, leading to a sudden slope failure that result *in landslides*

- Hot volcanic activity can melt snow and ice
- Melt water picks up rock and debris
- Forms fast flowing, high energy torrents
- Destroys all in its path

✓Flooding

- *Drainage systems* can become blocked by deposition of Pyroclastic flows and lava flows. Such blockage may create a temporary dam that could eventually fill with water and fail resulting in floods downstream from the natural dam
- Volcanoes in cold climates *can melt snow* and glacial ice, rapidly releasing water into the drainage system and possibly causing floods.

✓ Tsunami

- Debris avalanche events, landslides, caldera collapse events, and Pyroclastic flows entering a body of water may generate tsunami.

Forecasting volcanic activity

1. **Geophysical precursors**

- ✓ 1. *Earthquakes*. Nearly every eruption which has been monitored has been preceded by minor earthquakes or’’ micro seismic events.’’
- ✓ 2. **Topographic changes**. As the magma increases in volume or moves toward the surface there will be a bulging of the crust or an increase in the steepness of the slope of the volcano. These changes can be detected by sensitive leveling instruments called tilt meters.
- ✓ 3. **Changes in gravity field.** Magmas with densities different than the surrounding country rock will produce change in the local gravity field as they move toward the surface.
- ✓ 4. **Changes in magnetic and electrical fields.** Apparently, high temperatures influence both the magnetic susceptibility and the electrical resistivity of the rocks.

2. **Chemical precursors**

- ✓ Changes in **gaseous emanation** changes in both the volume and composition of gases frequently occur prior to an eruption.
- ✓ Temperature changes temperatures of crustal rocks increase as the magma makes its way toward the surface. There may also change the behavior of fumaroles and hot springs.

3. **Behavioral precursors**

- ✓ Animal behavior changes, Animals may leave an area or they may appear to be nervous or confused.

Mitigation measures

- Volcanic eruption *cannot be prevented*, but the damage associated with an eruption *can be reduced* in several ways,

1. By passing ***zoning*** laws that control the development permitted in hazardous areas.
2. By *planning for evacuation* and disaster relief in communities in high-risk areas.
3. By construction of *protective structures* such as diversion walls, levees, and ditches.
4. By controlling lava flows by *spraying water* on the advancing front or bombing the flow in order to control the direction of the movement.

Q?

- What should geologists do about volcanic eruptions in the future?
  1. Study volcanoes to find out more about how and why they erupt
  2. Monitor the volcanoes
  3. Develop hazard mitigation plans
  4. Understand the population around volcanoes, i.e. why do people choose to live near volcanoes?
  5. Education

Volcanic hazards in Ethiopia

- Ethiopia reports record volcanic eruption: *Addis Ababa (AFP) Nov 5, 2008*
- A volcano in Ethiopia's northeastern Afar region erupted on Monday, researchers said Wednesday, prompting a minor earthquake and record lava flows covering 300 square kilometres (115 square miles).
- "Satellite pictures showed that the volcano covered a record area of 300 square kilometres," the institute said in a statement, adding that no major damage to infrastructure or population displacement were immediately reported.
- Five people were killed and more than 2,000 displaced when an eruption occurred last year on the same mountain range.

Volcanic hazards in Ethiopia

- An eruption of a volcano in northeastern Ethiopia's Afar region left two people missing and forced hundreds of others to flee from flows of lava. The Ethiopia News Agency (ENA) said the volcano spewed lava on Sunday, forcing mainly salt-mining Afar nomads living in the mountainous region to evacuate.
- ENA did not provide the volcano's name, and it was not immediately known if it was Mount Erta Ale, the only active volcano in Ethiopia. It last erupted two years ago.
- That eruption expelled a thick blanket of ash and plumes of smoke that caused more than 50,000 Afar nomads to flee, and resulted in the deaths of hundreds of livestock.

-Global Volcanology Program

Some of Volcanoes in the *Afar rift*, *Ethiopia* which erupted in historical times

- **Dalaffilla, or Gabuli volcano**
- Dalaffilla, also referred to as Gabuli, is a small, but steep-sided conical stratovolcano that rises 300 m above surrounding lava fields SE of Alu volcano. This morphology, unusual for the Erta Ale Range volcanoes, results from the extrusion of viscous, silicic lava flows with primary slopes up to about 35 degrees. The first historical eruption of Dalaffilla took place in 2008, when lava flows from W and NW flank vents traveled to the NE.

Erta Ale

- Erta Ale is an isolated basaltic shield volcano that is the most active volcano in Ethiopia. The summit caldera is renowned for one, or sometimes two long-term lava lakes that have been active since at least 1967, or possibly since 1906. Recent fissure eruptions have occurred on the northern flank of Erta Ale.
- Dubbi, located east of the Erta Ale Range is a large volcanic massif that rises to 1625 m above the western shore of the Red Sea. An extensive basaltic lava fields to the north and NE, known as the Edd lava field, cover an area of 2700 sq km and reach the Red Sea coast. The two most-recent eruptive centers are fissure systems that extend NW-SE and NNE-SSW. The former produced lava flows that reached the Red Sea in 1400 AD. The second created 19 small craters at the summit in 1861.

Alayta shield volcano

- The massive Alayta shield volcano covers an area of 2700 sq km in the western Danakil depression SW of Lake Afrera. Two historical eruptions that were formerly attributed to Afderà volcano actually originated from Alayta. One of those eruptions, in 1907, produced a large lava flow from a SE-flank vent. Fumarolic activity occurs at two locations in the southern part of the complex.

Hydro-climatic Hazards

- **Climatic hazards: El Nino, La Nina, cyclones, drought, climate change, hurricanes, floods**
- **Hydro-climatic hazards Vs geologic hazards global inventory**
- **Hydrologic hazards: flooding, magnitude and frequency, urbanization and flooding**
- **Adjustments to flood hazards, perception of flooding, flooding hazards in Ethiopia**

Climatic hazards

- Climatic hazards are natural hazards caused by ***extreme weather*** events in an area. Such hazards ***affect a wider area*** and are ***more frequent than geologic hazards*** in many parts of the world. Such hazards include
- Climate change like EL Nino, La Nina, Global warming
- Storm
- Flooding
- Cyclones
- Thunder storms
- Drought
- Forest fires
- And other associated hazards occurring as a consequence of the above mentioned hazards: mudslides, landslides, fires, diseases…

1. El Nino

- The El Niño phenomenon in its original definition referred to ***warmer-than-normal temperature conditions on the ocean surface off the coast of Peru.***
- In recent times the definition has been expanded to refer to warmer-than-normal conditions on and near the equator in the eastern half of the Pacific Ocean.
- It is when ocean surface temperature fluctuates significantly from the norm
- El Nino = higher than normal, sustained anomalies of greater than 0.5 ºC are required

Naming: meaning of El Nino

- The phenomena is manifested around Christmas time, and thus is called El Niño (Spanish for the boy child) because it arrives at this time.
- An El Niño event occurs every 2 to 7 years with various degrees of strength.

The following table lists the years of El Niño events.

El Niño Years			
1902-1903	1905-1906	1911-1912	1914-1915
1918-1919	1923-1924	1925-1926	1930-1931
1932-1933	1939-1940	1941-1942	1951-1952
1953-1954	1957-1958	1965-1966	1969-1970
1972-1973	1976-1977	1982-1983	1986-1987
1991-1992	1994-1995	1997-1998	2002-2003
2006-2007	2009		

El Niño event occurs every 2 to 7 years with various degrees of strength, in recent years, the frequency of the event has increased !

A. "Normal" Conditions - Under "normal" conditions the easterly trade winds, driven by the pressure difference between the eastern Pacific (Western cost of South America) high and the western Pacific (Eastern cost of Australia) low and blowing toward the equator, push warm water toward the equator and across the Pacific Ocean toward Australia and Indonesia.

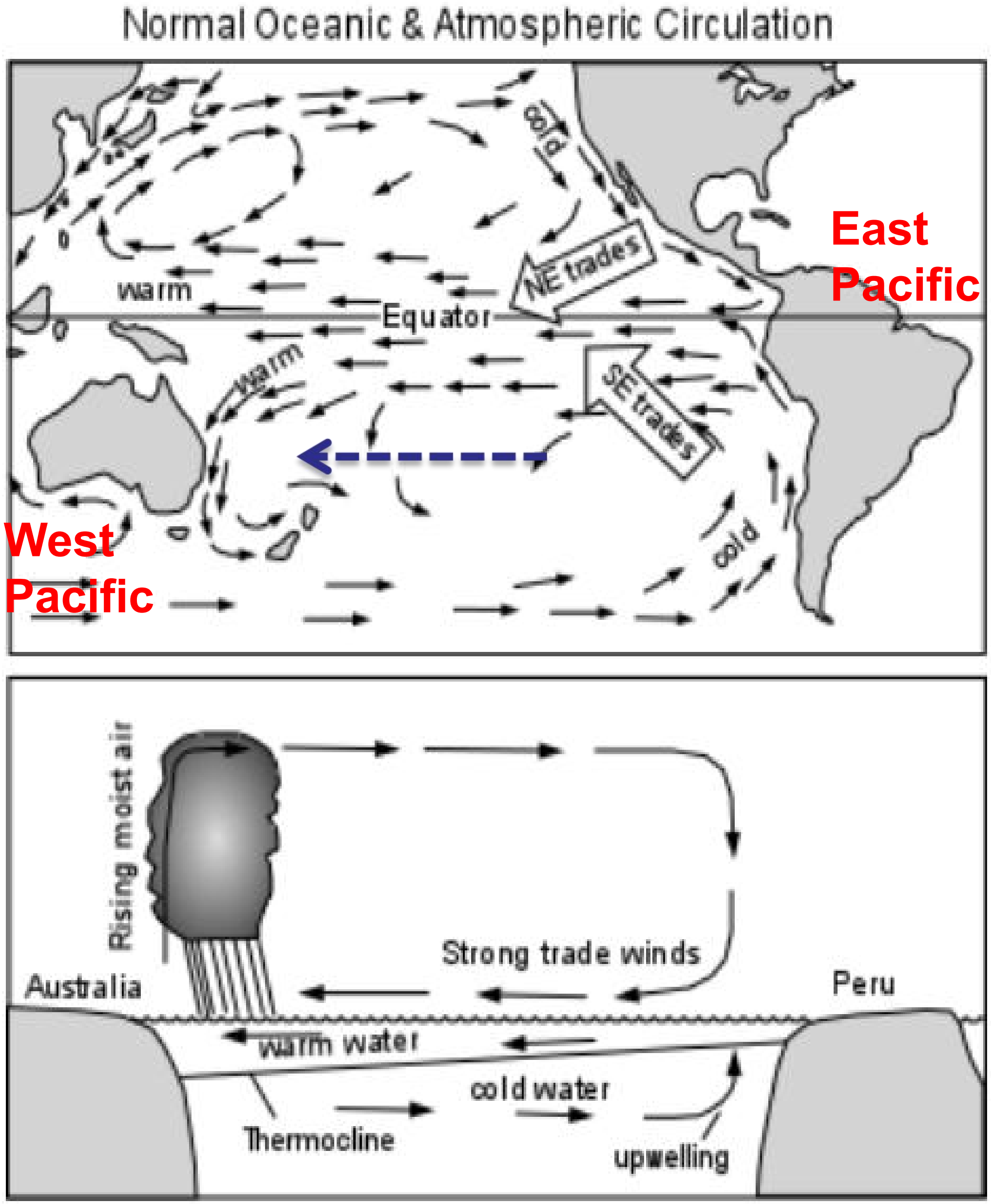
- This causes a pool of warm water to form near the equator in the western Pacific. It also causes the thermocline (the boundary between warm waters in the upper layers of the ocean and the cold deep waters below) to move closer to the surface off the coast of South America, bringing nutrient-rich waters to surface by upwelling.
- Such nutrient-rich waters help sustain large fish populations. The atmosphere above, and prevents rain clouds from forming off the coast of Peru upwelling cold water cools.

- The warm water pushed to the west by the trade winds, heats as it flows along the equator, so that on arrival in the western Pacific heat is added to the overlying atmosphere causing it to rise, form clouds, and produce extensive rainfall.

- The moisture depleted upper atmosphere then circulates back to east where it descends off the coast of South America contributing to the dry conditions.

- During periods of exceptionally strong trade winds the upwelling of cold water off the South America cools the water even further creating a condition called **La Niña (**girl child.

Normal Condition



B. El Niño Conditions - During El Niño periods there is a weakening of the easterly trade winds and the warm waters of the western Pacific are pushed toward the east.

- This causes the thermocline in the eastern Pacific to sink, preventing the upwelling of cold waters from below, depleting the waters in nutrients, and thus leading to starvation of fish populations.
- As the warm water shifts eastward so does the development of atmospheric disturbances that lead to upwelling of the atmosphere to form thunderstorms.
- Rising bodies of moist air thus occur closer to the coast of the Americas, leading to increased storminess, not only in South America, but in North America as well.
- These low pressure systems that develop in the eastern pacific can move over the continent and cause severe weather as noted above.

2. Cyclone

- A cyclone is an area that is surrounded by a wind system and has a low atmospheric pressure.
- **Tropical Cyclones** are massive tropical cyclonic storm systems with winds exceeding ***119 km/hr*** (74 miles/hour).
- The same phenomena is given different names in different parts of the world.
- In the Atlantic Ocean and eastern Pacific(around N & S Americas and the Caribbean) ocean they are called **hurricanes**.
- In the western Pacific(around Indonesia and Australia) they are called **typhoons**, and
- in the southern hemisphere and near the tropics, they are called **cyclones**.

- But, no matter where they occur they represent the same process.
- Tropical cyclones are dangerous because of their high winds, the storm surge produced as they approach a coast, and the severe thunderstorms associated with them.
- Although death due to hurricanes has decreased in recent years due to better methods of *forecasting* and establishment of *early warning systems*, the *economic damage* from hurricanes has increased as more and more development takes place along coastlines.
- It should be noted that coastal areas are not the only areas subject to hurricane damage.
- Although hurricanes loose strength as they move over land, they still carry vast amounts of moisture onto the land causing thunderstorms with associated *flash floods and mass-wasting hazards*.

Category	*Winds (MPH)*	*Damage*	*Storm Surge*
1	74 - 95	**Minimal**: Damage to unanchored mobile homes, vegetation & signs. Coastal road flooding. Some shallow flooding of susceptible homes.	4 - 5 feet
2	96 - 110	**Moderate:** Significant damage to mobile homes & trees. Significant flooding of roads near the coast & bay.	6 - 8 feet
3	111 - 130	**Extensive**: Structural damage to small buildings. Large trees down. Mobile homes largely destroyed. Widespread flooding near the coast & bay.	9 - 12 feet
4	**131 - 155**	**Extreme: Most trees blown down. Structural damage to many buildings. Roof failure on small structures. Flooding extends far inland. Major damage to structures near shore.**	**13 - 18 feet**
5	**More than 155**	**Catastrophic: All trees blown down. Some complete building failures. Widespread roof failures. Flood damage to lower floors less than 15 feet above sea level.**	**Greater than 18 feet**

3. Drought

Conceptual Definitions of Drought

- Drought is a extended period of deficient precipitation resulting in extensive damage to crops, resulting in loss of yield.

Meteorological Drought

- Meteorological drought is defined usually on the basis of the degree of dryness (in comparison to some “normal” or average amount) and the duration of the dry period.
- Definitions of meteorological drought must be considered as region specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region.
- For example, some definitions of meteorological drought identify periods of drought on the basis of the number of days with precipitation less than some specified threshold.

- Drought is a normal, recurrent feature of climate, although many erroneously consider it a rare and random event.
- It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another.
- Drought is a temporary aberration (abnormality); it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate.

4. Climate change

- Difference between weather and climate?
- **Weather** is the condition of the atmosphere at a particular time and place.
- It refers to such conditions of the local atmosphere as temperature, atmospheric pressure, humidity (the amount of water contained in the atmosphere), precipitation (rain, snow, sleet, & hail), and wind velocity.
- **Climate** refers to the average weather characteristics of a given region (Statistical description of weather).
- Climate, although it does change over longer periods of geologic time, is more stable over short periods of time like years and centuries

Climate Change…cont

- Climate change is defined as the change in climate attributed directly or indirectly to human activity which, in addition to natural climate variability, is observed over comparable time periods (over a period of at least 30 years).
- Earths climate has never been static, rather it has changed continuously in response to complex interaction among interior processes, the biosphere, the hydrosphere, the atmosphere, earths distance from the sun and variation in the intensity of solar radiation.
- But what are the causes of natural climate change?

A. Causes of natural climate change

- Changes in Earth's orbital parameters!

1. The **shape** of the **earth's orbit** is known to change over a period of 100 Ka; due to **planetary gravitational influences** : a process referred to as **eccentricity** of the orbit.
2. The **tilt of the earth's axis** varies from 21°39' to 24°36' over a time of 41 Ka, a phenomena called **obliquity** of the ecliptic (because the angle of tilt is measured relative to an imaginary line representing the plane of the ecliptic , the plane described by the earth's eclipital path around the sun)
3. Third variable: because of the **gravitational pool of the sun and the moon**, the earth **wobbles on its axis**, like a top, as a consequence, the **seasons** (the **equinoxes**) seem to move around the sun in a regular fashion, a term called **precession of the equinoxes,**

i.e. when the earth is **close** to the sun (**perihelion**) varies when it is **farthest** (**aphelion**), position **reverses** in 10.5 ka, a 21 ka complete cycle

- Total amount of radiation received is determined largely by the **eccentricity of earths orbit**.
- Other astronomical variables the way in which that heat energy is distributed **at different latitudes**.

B. Man induced climate change

- Man involved in changing the climate of our planate mainly by changing the Earth-Sun energy balance as a result of change in the chemistry of the atmosphere.
- Atmospheric chemistry changes when the concentration of specific gases increases above normal e.g. CO_2, CH_4, CFC's, …namely the **green house gases**

The green house effect

- CO_2 in the atmosphere has capacity to retain infrared radiations emitted from earth's surface. Earth's inner atmosphere gets hotter when the amount of infrared radiation retained increases due to more and more CO_2 and other green house gases released from industries.
- Atmospheric CO_2 concentration has almost doubled (from 170 ppm) before the industrial revolution, 1870's (to 370 ppm) this days. This is the main evidence for the assumption that industrialization is responsible for anthropogenic green house effects and for man induced climate change

5. Floods

- Throughout history humans have found it desirable to construct cities along streams.
- Streams are sources of water for consumption, agriculture, and industry.
- Streams provide transportation routes, energy, and a means of disposal of wastes. Stream valleys offer a relatively flat area for construction.
- High amounts of water flowing in streams often leads to flooding, and flooding is one of the more common and costly types of natural disasters.

❖ A flood results when a stream runs out of its confines and submerges surrounding areas.

- They usually are caused by **intense storms** that produce more runoff than an area can store or a stream can carry within its normal channel.
- **Periodic floods**: occur naturally on many rivers, forming an area known as the flood plain.
- These river floods usually result from heavy rain, sometimes combined with melting snow, which causes the rivers to overflow their banks.
- **Flash flood**: is a flood that rises and falls rapidly with little or no advance warning.
- Flash floods usually result from intense rainfall over a relatively small area.
- Rivers can also flood when **dams fail**, when **ice jams** or **landslides** temporarily block a channel, or when snow melts rapidly.

Effects of flooding

- In **less developed** countries, humans are particularly sensitive to flood casualties because of
- ✓ high population density,
- ✓ absence of zoning regulations,
- ✓ lack of flood control, and
- ✓ lack of emergency response infrastructure and early warning systems

- In **industrialized countries** the loss of life is usually lower because of

✓ flood control structures,

✓ zoning regulations that prevent the habitation of seriously vulnerable lands,

✓ emergency preparedness.

➢ Still, **property damage** and disruption of life takes a great toll, and despite flood control structures and land use planning, floods still do occur.

Causes of flooding

How do floods form naturally?

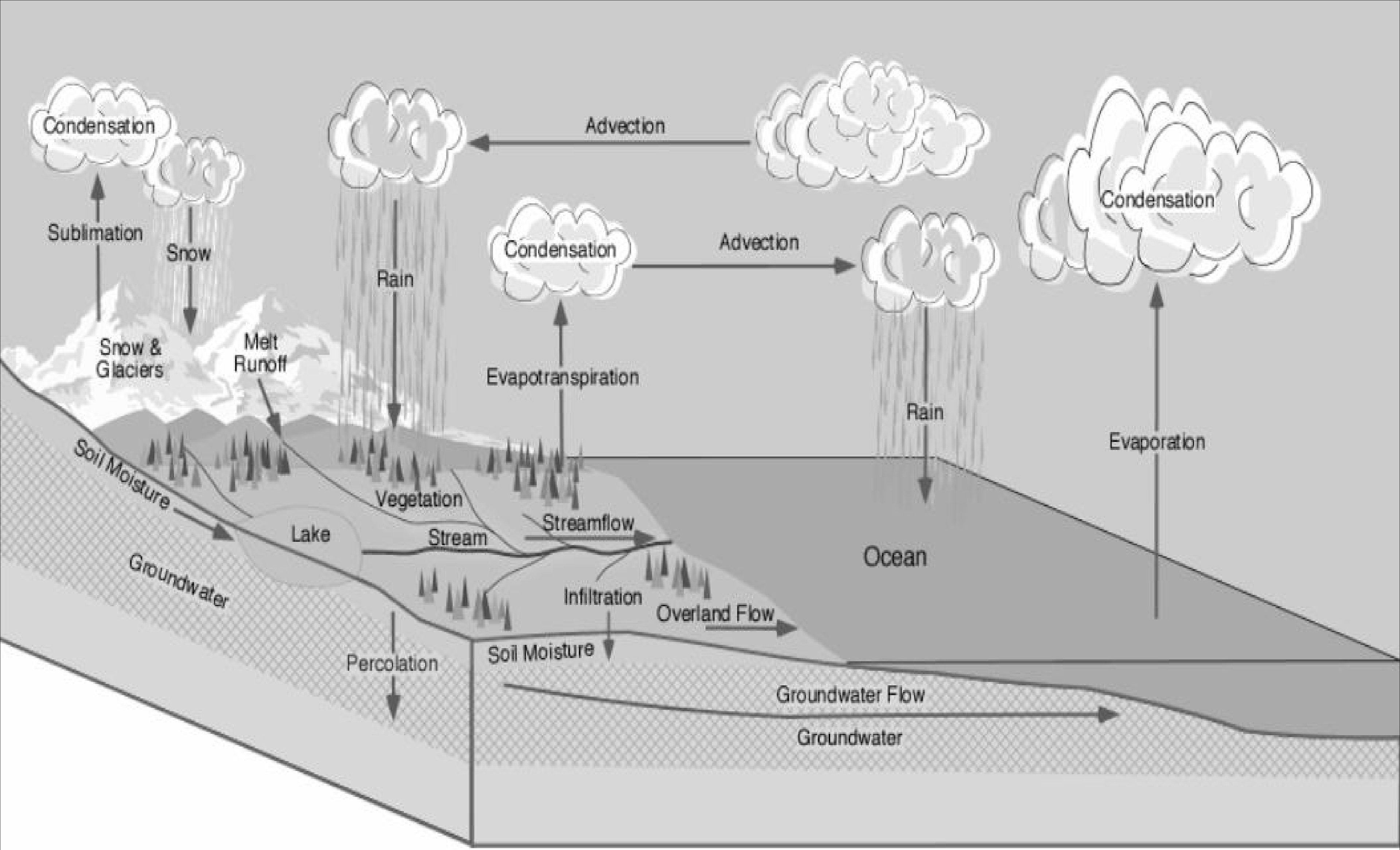
A. River flooding

- From a geological perspective, floods are a natural consequence of stream flow in a continually changing environment, it will continue as the water cycle continues to run

➢ The Role of **Precipitation**

- When the amount of water flowing in to one area is greater than the capacity of the system to hold it within natural confines, flooding can result.

- Exceptional precipitation, heavy snow melts, water saturated ground, unusually high tides, and drainage modifications can lead to flooding



Which components of the hydrologic cycle are directly involved in the flooding phenomena?

B. Coastal flooding

- The role of **Costal Flood**

- Areas along coastlines become subject to flooding as a result of tsunamis, hurricanes, and unusually high tides.
- In addition, long term processes like subsidence and rising sea level as a result of global warming can lead to the encroachment of the sea on to the land.

❖**Other causes of flooding**: due to man made and natural factors

➢ ***Dam & Levee Failures***

- Dams occur as both natural and human constructed features.
- Natural dams are created by volcanic events (lava flows and pyroclastic flows), landslides, or blockage by ice.
- Human constructed dams are built for water storage, generation of electrical power, and flood control.
- All types of dams may fail with the sudden release of water into the downstream drainage.

Example: Flooding caused by Dam failure

- The Banqiao dam failure, China
- The dam failure which killed the largest people ever!

- Built in 1951/52, Dam height=116meters, with total capacity of reservoir was 492 million m^3, The Dam was designed to survive a 1-in-1,000-year flood (300 mm of rainfall per day). In August of 1975, however, a 1-in-2,000 year flood occurred

- Failed in 1975 due to over flooding. A 10 Km wide and 3-7m high river water stormed, wiped off an area 50Km long and 15Km wide, and produced a temporary lake of 1200Km2 area. It has been reported that around 90,000 - 230,000 people were killed as a result of the dam breaking.

Stream systems:

- A stream is a body of water that carries rock particles and dissolved ions and flows down slope along a clearly defined path, called a channel

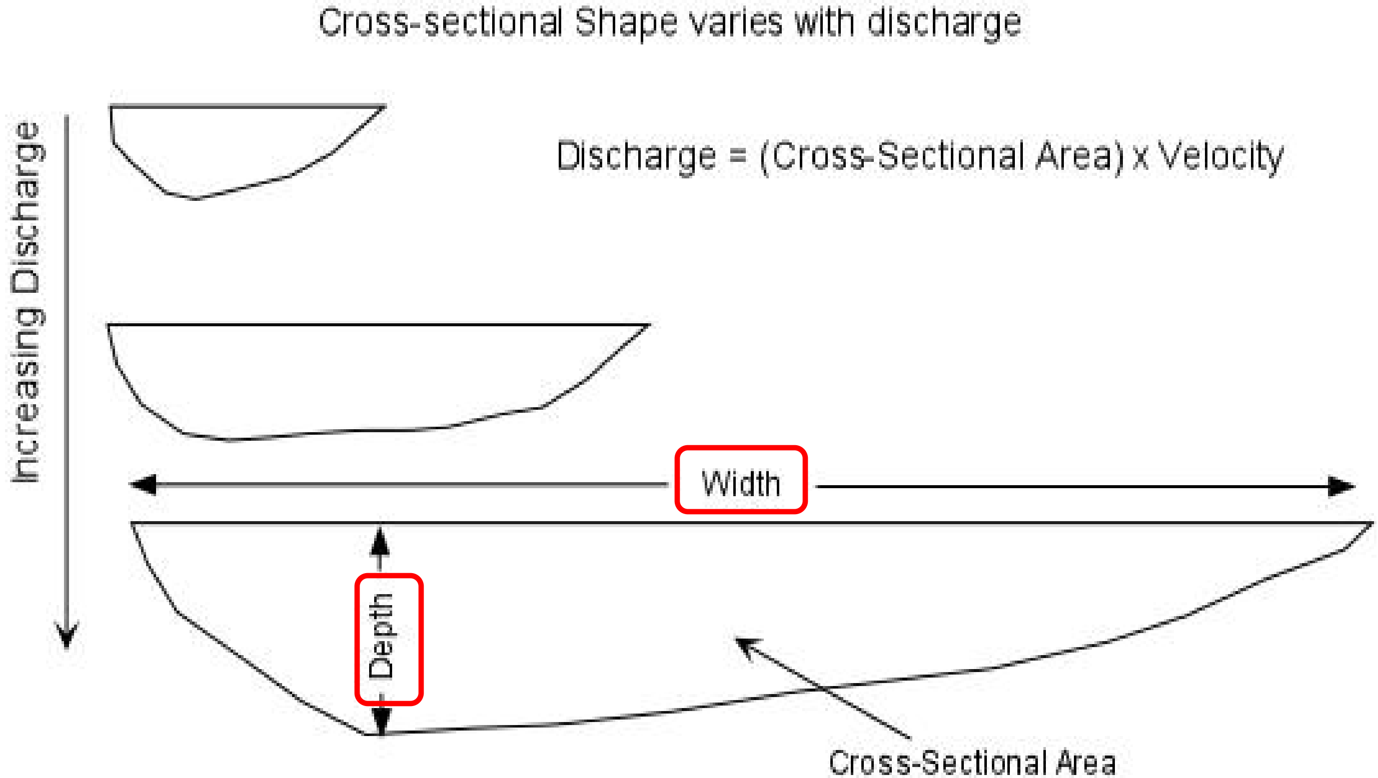
Geometry and Dynamics of Stream Channels

- The stream channel is the conduit for water being carried by the stream.

Cross Sectional Shape:

- varies with position in the stream and discharge
- The deepest parts of a channel occur where the stream velocity is the highest.

Both **width** and **depth** increase downstream because **discharge increases** downstream.



- Discharge: The volume of water passing any point on a stream.
- Discharge is measured in units of volume/time (m^3/sec). **Q = A x V** Discharge (m^3/sec) = Cross-sectional Area (width x average depth)(m^2) x Average Velocity(m/sec)

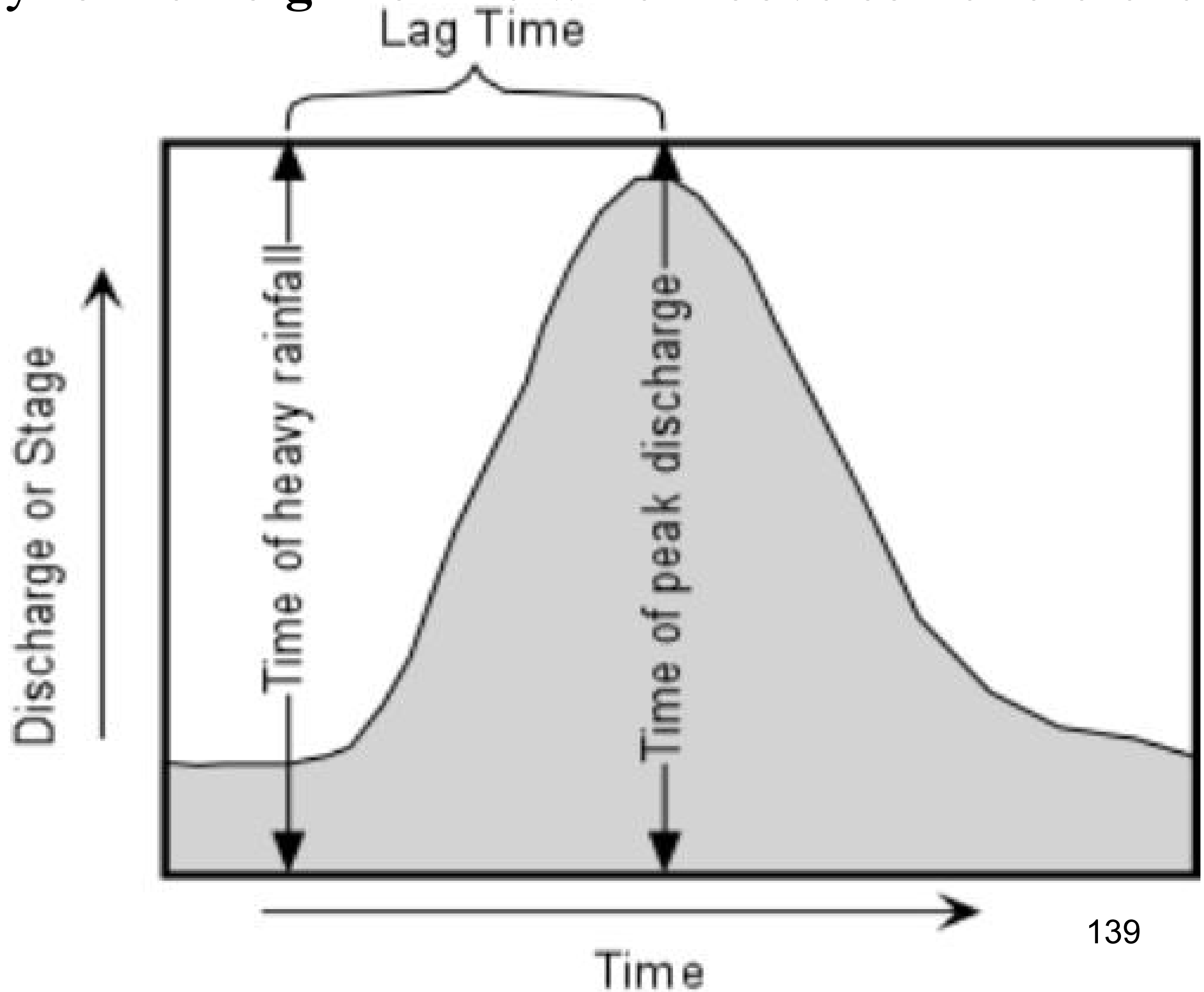
River Flooding

- Having covered the basics of stream systems we now turn our attention to the details of flooding associated with rivers and streams.

Flood Stage

- The term **stage** refers to the *height of a river* (or any other body of water) above a locally defined elevation.
- This locally defined elevation is a reference level, often referred to as **datum**.
- Measurements of a river's stage and discharge are plotted on a graph called a ***hydrograph***, which shows the stage or discharge of the river, as measured at the gauging station, versus time.
- When the discharge of a river increases, the channel may become completely full.
- Any discharge above this level will result in the river overflowing its banks and causing a flood.
- The stage at which the river will overflow its banks is called **bank full stage** or **flood stage**

- Discharge is not linearly related to stage because discharge depends on both the depth and width of the stream channel, or more precisely, on the **cross-sectional shape** of the channel.
- Stage refers only to the **height** of the water above some reference level.



River hydrograph

Factors that Affect Flooding

- As discussed previously the main factors that cause flooding are heavy rainfall, heavy snow melt, and dam failure
- Here we discuss the main cause of flooding, that is heavy rainfall over a short period of time!!!

- When rain falls on the surface of the Earth,

✓ Some of the water is **evaporated** back to the atmosphere,

✓ Some of it **infiltrates** the soil and moves downward to groundwater system, and

✓ Some is **intercepted** by depressions and vegetation.

❖ **What remains on the surface** of the Earth and eventually flows into streams is called ***runoff***.

- **Infiltration**: controlled by how readily the water can seep into the soil, be absorbed by the soil, ***Several factors*** determine the rate of infiltration

i. **Saturation of the soil**: If the soil is already saturated with water and the water table has risen as a result of rainfall prior to a heavy storm, then little further water can infiltrate the soil, and the rate of infiltration will be highly decreased

ii. **Vegetation**: can aid infiltration by slowing the flow of water over the surface and providing passageways along root systems for water to enter the soil.

- In desert regions or areas that have recently been deforested either by fires or humans, infiltration will be reduced, thus increasing the rate of runoff and decreasing the lag time

iii. Soil types: (dependent on climate): Different soil types have different capacities to absorb moisture.

- Soil type is to a large extent dependent on climate.
- For example a type of soil that forms in dry, desert-like environments has a thin layer of poorly developed soil overlying a crust of cliché.
- Caliche is calcium carbonate that has precipitated out of water infiltrating through the thin soil.
- The caliche zone acts as an impermeable layer.
- Such soils in deserts, combined with the lack of vegetation make flash flooding in desert areas more common.

iv. Human construction: Humans tend to pave the Earth with such things as parking lots, highways, sidewalks, and plazas that prevent infiltration of water into the soil.

- Furthermore they tend to channel the water into storm sewer systems and concrete lined drainages, all of which increase runoff and decrease infiltration.

- When rain falls on the surface of the Earth, some of the water is evaporated and returns to the atmosphere, some of it infiltrates the soil and moves downward into the groundwater system, and some is intercepted by depressions and vegetation.
- What remains on the surface of the Earth and eventually flows into streams is called runoff. In general, then: **Runoff = (Precipitation- Infiltration - Interception – Evaporation)**

- *Evaporation* tends to be the least of these quantities, particularly over short periods of time, and thus precipitation, infiltration, and interception are the most important variables that determine runoff and eventual discharge into streams

Factors Affecting the Severity of Floods

Natural features of the area and the **land-use practice**

A. Natural features/factors

Natural features may be viewed as *physical-topography, soils, bed-rocks geology, vegetation, amount of moisture in soil before rainfall and the quantity, intensity, and distribution of rainfall.*

Example: High antecedent moisture conditions, steep slopes, and impermeable soils or bedrock will combine to produce a high rate of runoff, which may exceed the carrying capacity of a stream even rainfall is moderate

B. Land-use practice

- ✓ land-use practices may greatly increase the severity of flooding by increase the **rate of runoff**.
- ✓ In **urban areas**, buildings and pavement seal off water-absorbing ground, or construction activities may leave land bare and subject to runoff. Because storm
- ✓ sewers often lead directly to stream channels, large volumes of water can be emptied in to stream in a short period of time.
- ✓ In rural area, unwise agriculture practices remove protective vegetation
- ✓ inadequately designed dams, which may fail and produce catastrophic floods.
- ✓ Also, buildings and other structures may be floated off their foundation, becoming destructive against other property / interfere with flow, causing an increase in the size of the area inundated.

Flood Hazard Assessment

- Some of the hydrologic variables of interest to planners and engineers in evaluating flood risk are:

1. Frequency: e.g. once in 50 yrs/100 yrs
2. magnitude: in m^3 / sec
3. rate of rise: rapid up stream than downstream
4. flood peak: greatest water elevation
5. lag time: interval b/n peak rainfall & peak discharge/flow
6. duration: the time of inundation

Reducing Loses from flooding

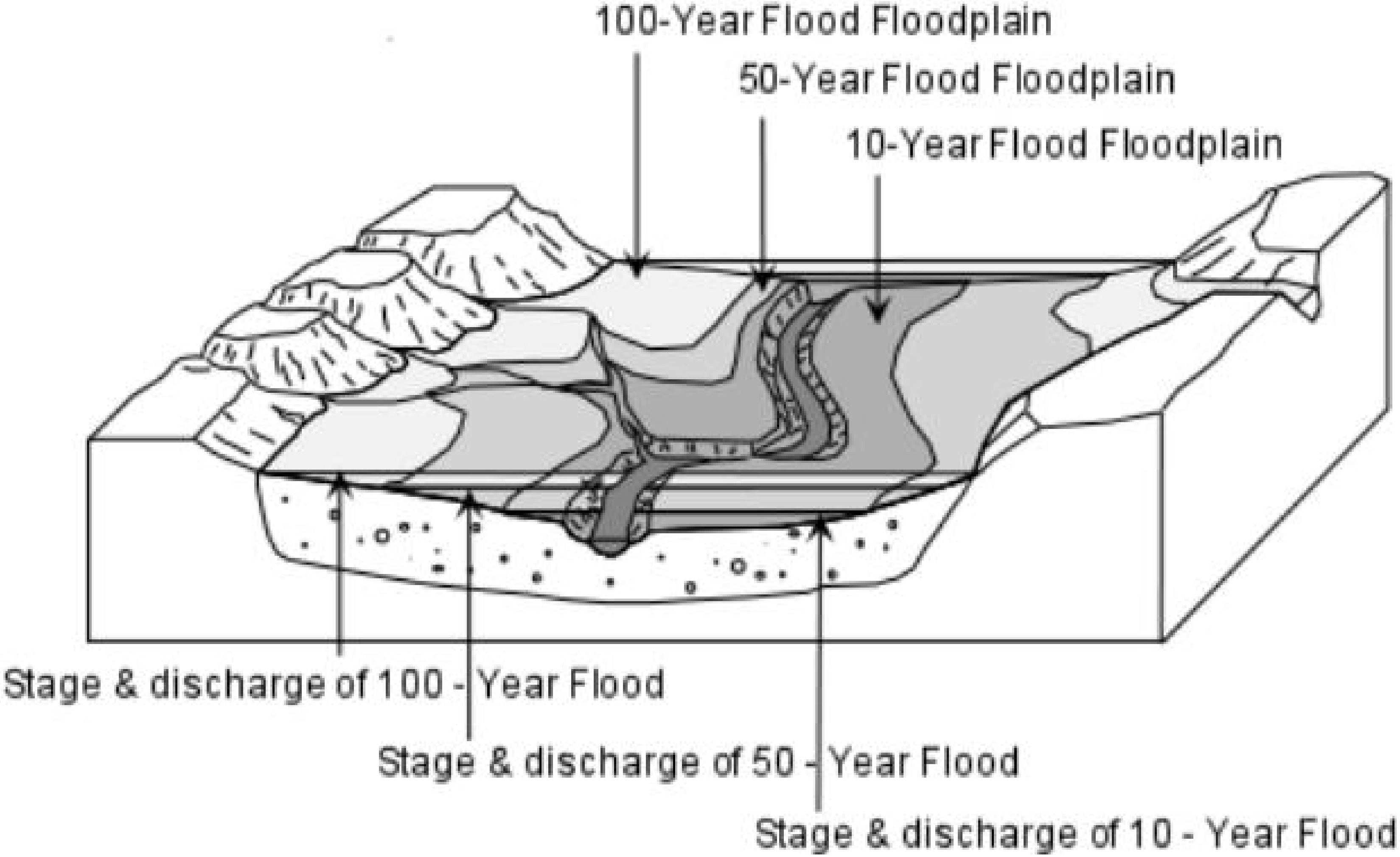
1. **Structural controls**

- dams, reservoirs,
- diversion channels,
- dikes, and levees, and channel dredging,
- straightening, and widening.

2. **Non-structural controls**

- Flood-plain zoning
- restrictions on the use of land on flood
- pass laws that prevent uncontrolled building or development on flood plains

- Flood hazard zoning map produced based on historical flood records in an area. Different flood stages cover different flooding zones at different distances from the river channel.



Hydro-climatic hazards Vs geologic hazards global inventory

- Compare Hydro-climatic hazards Vs geologic hazards for the case of Ethiopia. Which one of the two hazards are more common in our country?

El Nino, La Nina, cyclones, *drought*, climate change, hurricanes, *floods*…	Vs	Volcanism, earthquakes, *Landslides*, subsidence, tsunamis, other geohazards…

Flooding hazards in Ethiopia

- As the topography of the country is rather rugged with distinctly defined watercourses, large scale flooding is limited to the ***lowland flat parts*** of the country.
- However, intense rainfall in the highlands causes flooding of settlements in a number of river basins.
- One of these is the **Awash River Basin**
- located in the Rift Valley and with a surface area of about 113,000 km2, which has the largest level of development.
- On the other hand, the level of the waters of two main lakes has been gradually increasing causing damage to infrastructure in a number of areas.
- Finally, torrential floods are also produced in Addis Ababa and in another main city.

Nature of flooding in Ethiopia

- The rainy season in the country is concentrated in the three months between June and September, when about 80% of the rains are received.
- Torrential downpours are common in most parts of the country.
- Large scale flooding is rare and limited to the lowland areas
- The most serious flood problems are found in the abovementioned Awash River basin
- It is estimated that in the Awash Valley almost all of the area delineated for irrigation development is subject to floods; this amounts to an inundated surface of some 200,000-250,000 ha during high flows.

- The other rivers where significant floods occur are the Wabi-Shebelle River in southeastern Ethiopia near the Somali border and Baro-Akobo/Sobat River in western Ethiopia, near the Sudanese border.
- In the Baro-Akobo Plain an area of about 300,000-350,000 ha is prone to annual flooding and in the Wabi-Shebelle Basin some 100,000 ha may be inundated.

Landslides

Chapter content:

- **Introduction to Landslides, slope processes and types of landslides, slope stability**
- **Landslide hazards**
- **Minimizing the landslide hazard, perception of the landslide hazard**
- **Landslide hazard in Ethiopia**

Introduction to Landslides-definition

- Landslide is a general term covering a wide variety of landforms processes involved in mass movement.
- The down-slope movement of material, whether it is bedrock, regolith, or a mixture of these, is commonly referred to as a landslide.
- All of these processes generally grade into one another, so classification of mass-wasting processes is somewhat difficult.

Landslides distinguished based on

type of movement:

- Falling,
- flowing, or
- sliding.

type of material sliding:

bedrock, soils /sediments or mixture of both

Some classification schemes emphasize rate of movement-**slow or rapid.**

Landslide, also known as mass movement

- Is the down-slope movement of surface material in response to gravitational forces without the aid of a transporting medium such as water, ice, or wind.
- As human populations expand and occupy more and more of the land surface, ***mass wasting*** processes become more likely to affect humans,
- Knowledge about the relationships between local geology and mass-wasting processes can lead to better planning that can reduce vulnerability to such hazards

Slope processes and types of landslides

1. **Fall-**involves a *very rapid downward* movement of earth material. Rock falls occur when a piece of rock on a *steep slope* becomes dislodged and falls down the slope (Fig.1).

- **Debris falls:** are similar, except they involve a *mixture* of soil, regolith, and rocks.
- **Rock fall:** may be a single rock, or a mass of rocks, and the falling rocks can dislodge other rocks as they collide with the cliff. At the base of most cliffs is an accumulation of fallen material termed talus.

2. Flows-move at variable rates, consist of unconsolidated material, and resemble a *viscous fluid*.

- Often they have a distinctive hourglass shape, with a bowl-shaped source area leading to a relatively narrow neck followed by bulge at the base.
- Most flows occur during or after period of heavy rainfall.
- Movement can occur on fairly *gentle slopes* and cover distance of several kilometers.

3. Slides-involves very rapid to very slow movement along surface of shear failure.

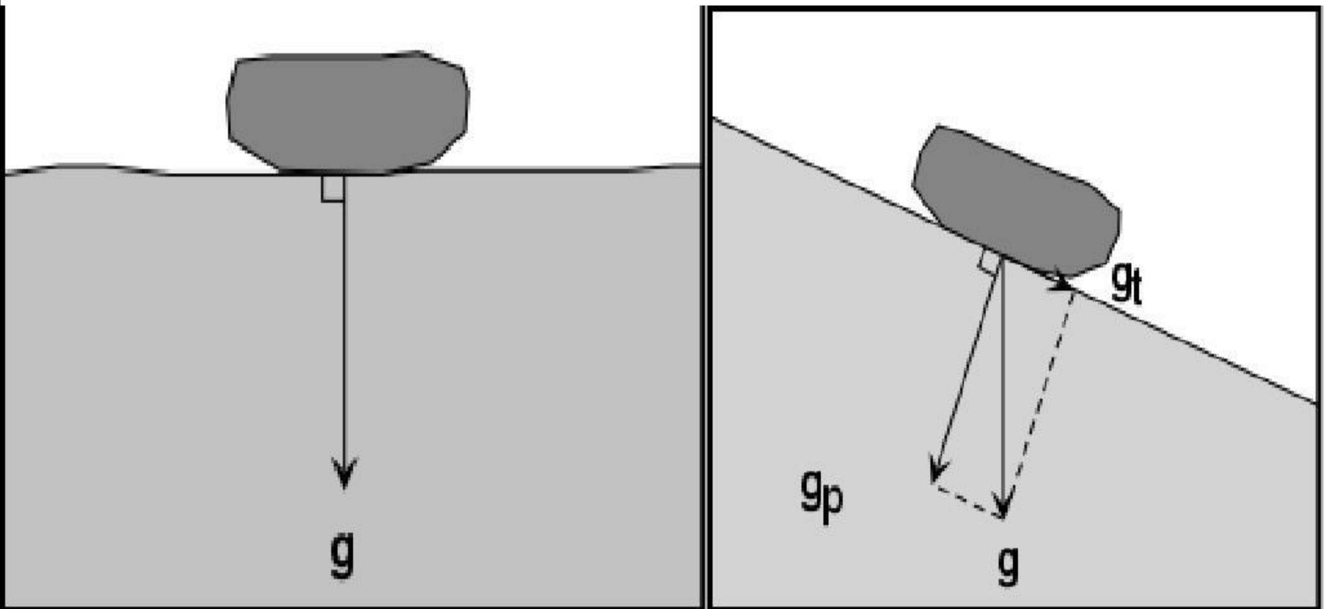
- Two basic patterns of movement are associated with slides- Rotational slide/slump and Translation slide.
- **Translation slides:** occur along planes of weakness, such as bedding planes, fractures and clay lamina.
- The slip surface follows the plane of weakness.
- **Rotational slide:** the slip surface, or surface of rapture, is *concave* upward or spoon-shaped, leading to a backward rotation in the displaced mass

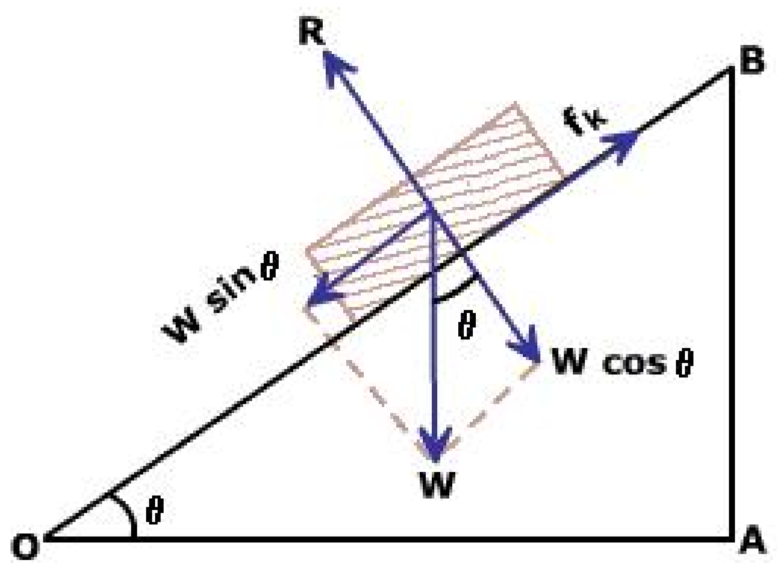
Cause of Landslides

A. Gravity

- The main force responsible for mass wasting is gravity.
- Gravity is the force that acts everywhere on the Earth's surface, pulling everything in a direction toward the center of the Earth.
- So long as the material remains on the flat surface it will not move under the force of gravity.
- On a slope, the force of gravity can be resolved into two components: a component acting perpendicular to the slope and a component acting tangential to the slope.

components of the force of gravity





Body accelerating down an inclined plane

B. Slope stability

- Mechanism of slide (slope stability): Deriving force working against resisting force. A material will slide when the component of force caused by gravity and directed downward the inclined plain is greater than the friction force holding the material in place.

$$\text{Safety factor (FS)} = \frac{\text{Resisting Force (shear strength)}}{\text{Driving force (shear stress)}}$$

- if resisting force > deriving force, stable slope
- if deriving force > resisting force, unstable slope

“SF” is the safety factor.

The **driving** forces include:

- The weight of the material
- The gradient of the slope
- Ground vibration

Resisting forces include:

- Strength
- Cohesion of the material
- Friction

The safety factor is reduced when:

1. there is a reduction of the factors that resist failure (shear strength)
2. There is an increase in factors that promote failure (shear stresses)

When the safety factor is less than or equal to 1.0, movement is likely to take place.

The factors leading to landslide may be viewed as either external or internal.

The most common **external factors** are:

1. steep topographic slope
2. removal of support at the toe/slope modification
3. overloading the crown of the slope
4. ground vibration
5. Change in vegetation cover.

These factors may be related to natural process and/or human activities.

Most common **internal factors** are

1. An increase in moisture content as it relates to weight and pore-water pressure
2. structures such as bedding planes, joints, foliation, cleavage, faults, cavities, etc
3. composition, such as the presence of water soluble minerals and expansible clays
4. Weathering by solution, hydration, freeze-thaw, and so on.

Triggering mechanisms

Both external and internal factors may act together over long period of time to greatly reduce slope stability.

However, **abrupt failure** may triggered by a single event such as

- heavy rainstorm,
- Earthquake,
- volcanic eruption,
- rapid drawdown of reservoir, or a large scale excavation.

Minimizing the landslide hazard

Landslide Prevention

There are a number of practical and cost effective ways to prevent some landslides;

1. Passage of zoning laws that would control the development of unstable areas.
2. Establishment of grading codes that would maintain slope integrity during construction projects.
3. Control of drainage through diversion ditches, shallow wells, or horizontal tiles.
4. reducing the load on the head of a slope
5. grading a slope to reduce the gradient
6. Buttressing the toe of slope with retaining structures

7. Planting slopes with vegetation with extensive root systems and high rates of evapotranspitration.
8. Treatment of surficial materials with chemical solutions which promote stabilizing ion exchanges.
9. Grouting rock formations with cement to reduce pore water and increase shear strength.

Landslide hazard in Ethiopia

- In the densely populated **highland** area of Ethiopia, where altitudes exceed 1750 m, the increase in the number and size of landslides during the last 30 years is causing considerable concern among the society.
- From 1993 to 1998 alone, about 300 lives have been lost, more than 200 houses demolished, greater than 100 km of road damaged and in excess of 500 ha of land devastated.

- Landslide hazard is one of the crucial environmental constraints for the development of Ethiopia, representing a limiting factor for urbanization and infrastructures.
- The **high relief** and the rugged topography induced by a strong Plio-Quaternary uplift, the occurrence of **clayey** horizons within the sedimentary sequences, the dense network of tectonic fractures and faults, the thick volcanic outcrops, and the thick colluvial–alluvial deposits at the foot of steep slopes are the predisposing factors for a large variety of mass movements.
- Heavy summer rainfall is the main triggering factor of most landslides, some of which undergo a step-like evolution with long-lasting quiescence intervals.

Landslide in Ethiopia….on the *NEWS*

APA-Addis Ababa (Ethiopia) At least 19 people died and more than 20 were injured by a landslide in Ethiopia due to the on-going heavy rains in the country, Ethiopian police said here on Wednesday. The landslide occurred late on Tuesday following heavy rains in a town called Mersa, in the Amhara regional state, located some 500 kilometres north of Addis Ababa.

25 August 2010

Landslides in Ethiopia kill 11, injure 8, destroy numerous homes

- **Addis Ababa (dpa)** - Landslides due to torrential rain killed 11 people, seriously injured eight and destroyed 102 homes in a remote rural area in southern Ethiopia, local press reported Sunday.
- The tragic incident occurred last Tuesday in two rural farm localities in the Detta Woreda district of Gamo Goffa Zone in the South Ethiopia Region, the Amharic language daily, Addis Zemen reported.

31 Aug 2003

Global Water Resources

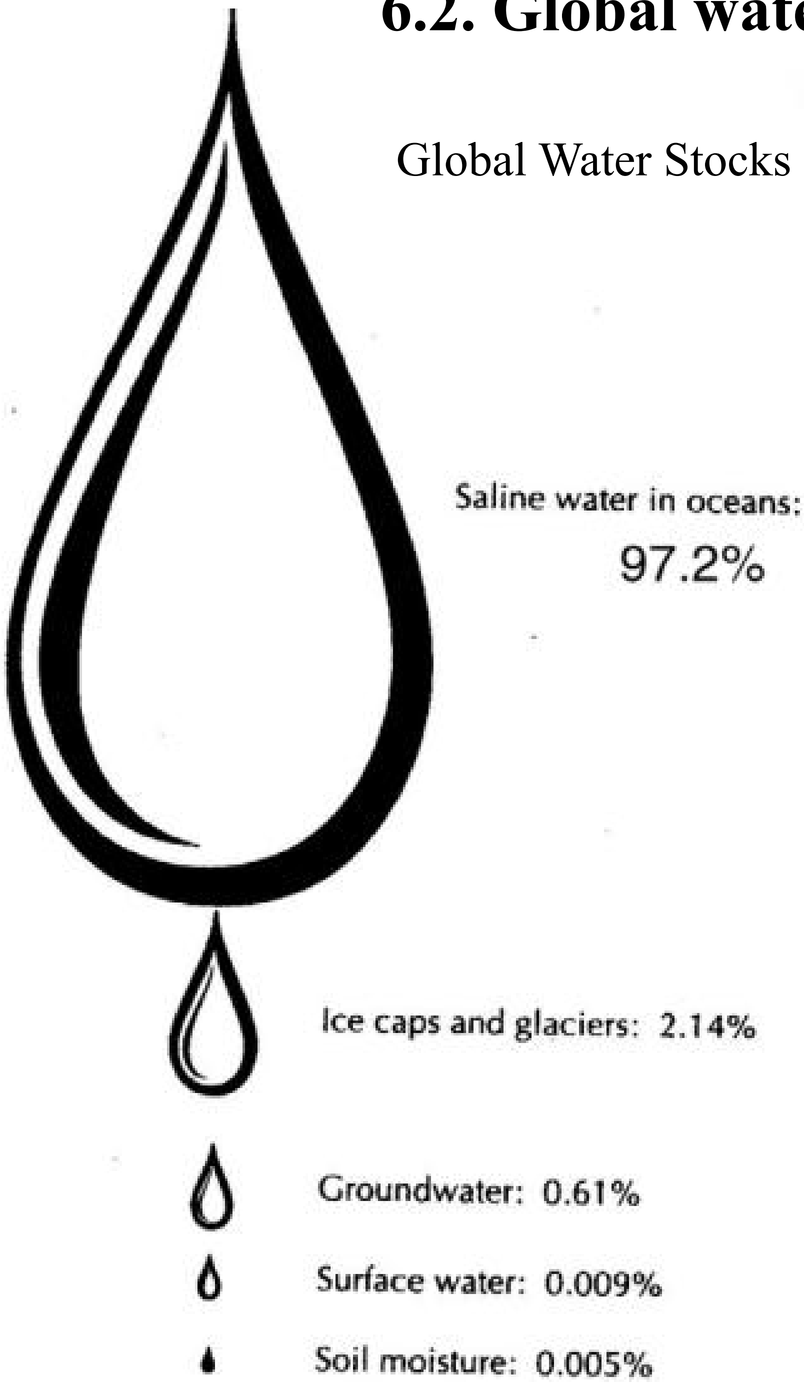
- **Chapter content**
- Global water balance, global water supply and demand
- Mechanics of groundwater
- Conflict on water resources
- Groundwater as environmental, social and economic good
- Concepts of integrated water resources management
- Human impact on groundwater

6.1. Global water balance

- The global water cycle involves the movement or transfer of water from one of earths storage components, such as the ocean, lakes, and the atmosphere to another.
- Major processes involved in the cycle are:
- Evaporation
- Precipitation
- Transpiration
- Surface runoff
- Sub surface groundwater flow

- The annual volume of water transferred from the ocean to the land is balanced by the same volume returning by river and groundwater flow to the ocean and there is a balance between total evaporation and precipitation.
- Water never leaves the Earth. It is constantly being cycled through the atmosphere, ocean, and land. This process, known as the **water cycle**, is driven by energy from the sun. The water cycle is crucial to the existence of life on our planet.

6.2. Global water supply and demand



Distribution of Water:

- Total Volume –1400 million km^3
- ✓ Oceans –97.2%
- ✓ Land –2.8%
- ✓ Atmosphere –0.001%
- ✓ Land –2.8% of total
- ✓ Glaciers and ice caps –77.4%
- ✓ Groundwater –22.1%
- ✓ Surface fresh water –0.4%
- ✓ Soil moisture –0.2%

Note: of consumable fresh water groundwater is 98%.

Global water supply and demand

Global surface water distribution

- Only 2% of the global water stock is fresh water, 87% of this freshwater is found locked in ice caps and glaciers or stored deep in underground
- Only 0.01% of all water on earth is available in the form that supplies the needs of more than 90% of the world's population-river, runoff and lakes.
- Surface water, the most critical of our freshwater resources, is distributed unequally among and within the continental landmasses.
- Increased population and per capital consumption of freshwater, the demand for freshwater has exceeded its availability in many parts of the world.

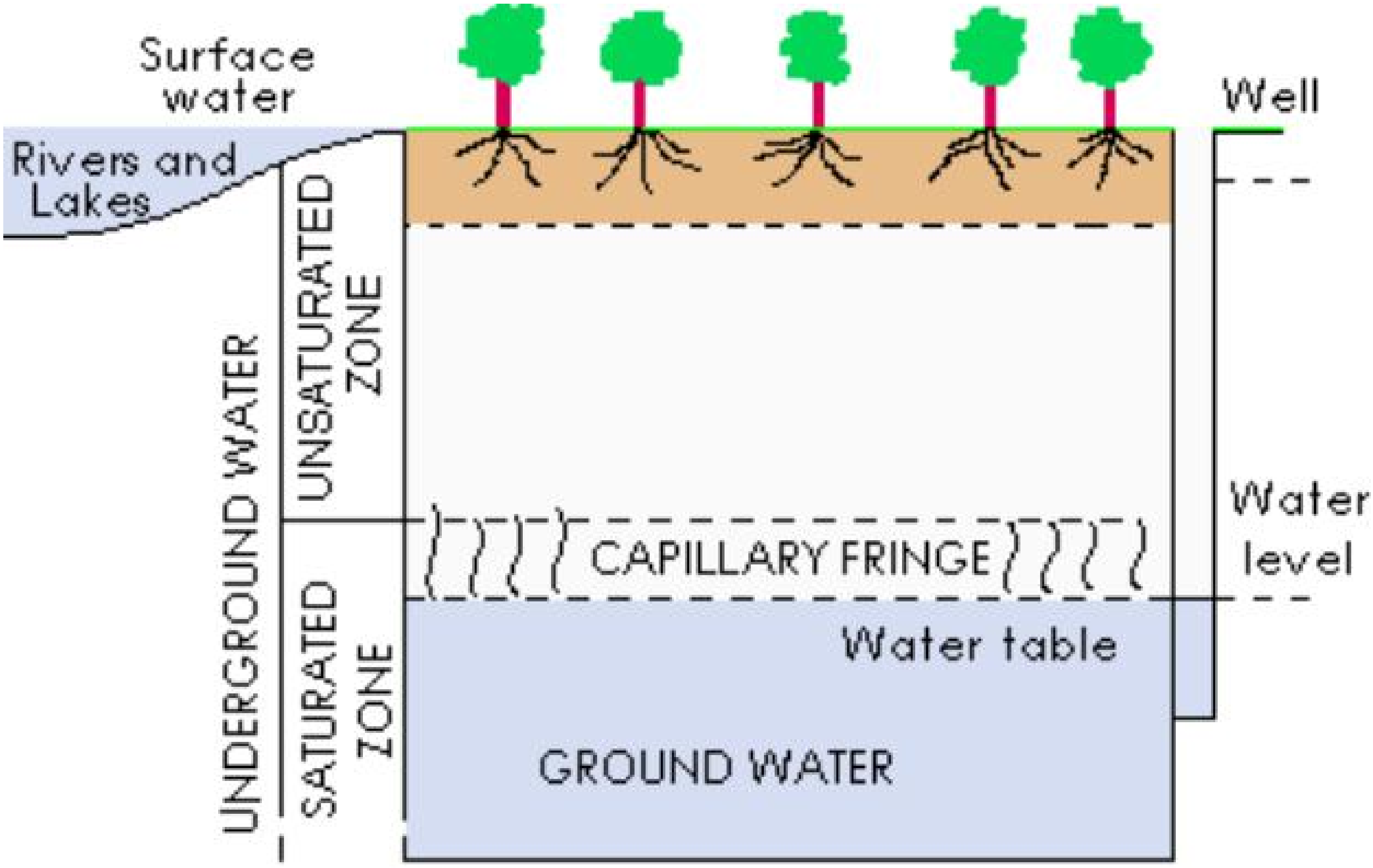
- Difference in the water supply are related to the *distribution of average annual precipitation, *evapotranspiration (the combination of evaporation from water and land surfaces and transpiration of water vapor from plants) and *runoff.
- If precipitation exceeds evapotranspiration, water is available to fill surface basins and channels and to infiltrate the pedosphere (the soil system) and recharge the groundwater system.
- If precipitation amount is less than evapotranspiration, water deficit will occur.

6.3. Mechanics of groundwater

- Water in the ground, like water on earth's surface or water vapor in the atmosphere, is in motion because it has energy. Water enters as an excess surface water, and steps downward because of gravity and the porous nature of soil and rocks.
- Water continues to move underground, to the oceans and the base level of rivers. From the oceans and the continental surface, water molecules evaporate to the atmosphere and contribute to rainfall.
- All the time, water is entering and leaving the groundwater system, forming an essential link in the global hydrologic cycle of water.

- Rainfall infiltrate the subsurface and drain downward through any underlying unsaturated material along interconnected pore spaces.
- At the point where all the voids are saturated, infiltrating water becomes part of the groundwater.
- The boundary between the unsaturated and saturated zones forms a surface called the water table.
- All water bellow earths surface is underground water and only the water below the water table is called groundwater.
- Elevation and groundwater pressure determine the direction of groundwater flow. The water table mimics topography and freely moving groundwater flows from places of high elevation to low elevation.

Figure: saturated and unsaturated zones



Important terms: **Porosity**, **permeability…and** their contribution to **contaminants transport** in the groundwater

- **Porosity**: the ratio (denoted as %), of void space to total volume of a rock or sediment. The more porous the rocks and sediments in an area, the more amount of groundwater that can be stored. E.g. well sorted conglomeritic sandstone, loose sediments, alluvial sand materials, vesicular basalt…

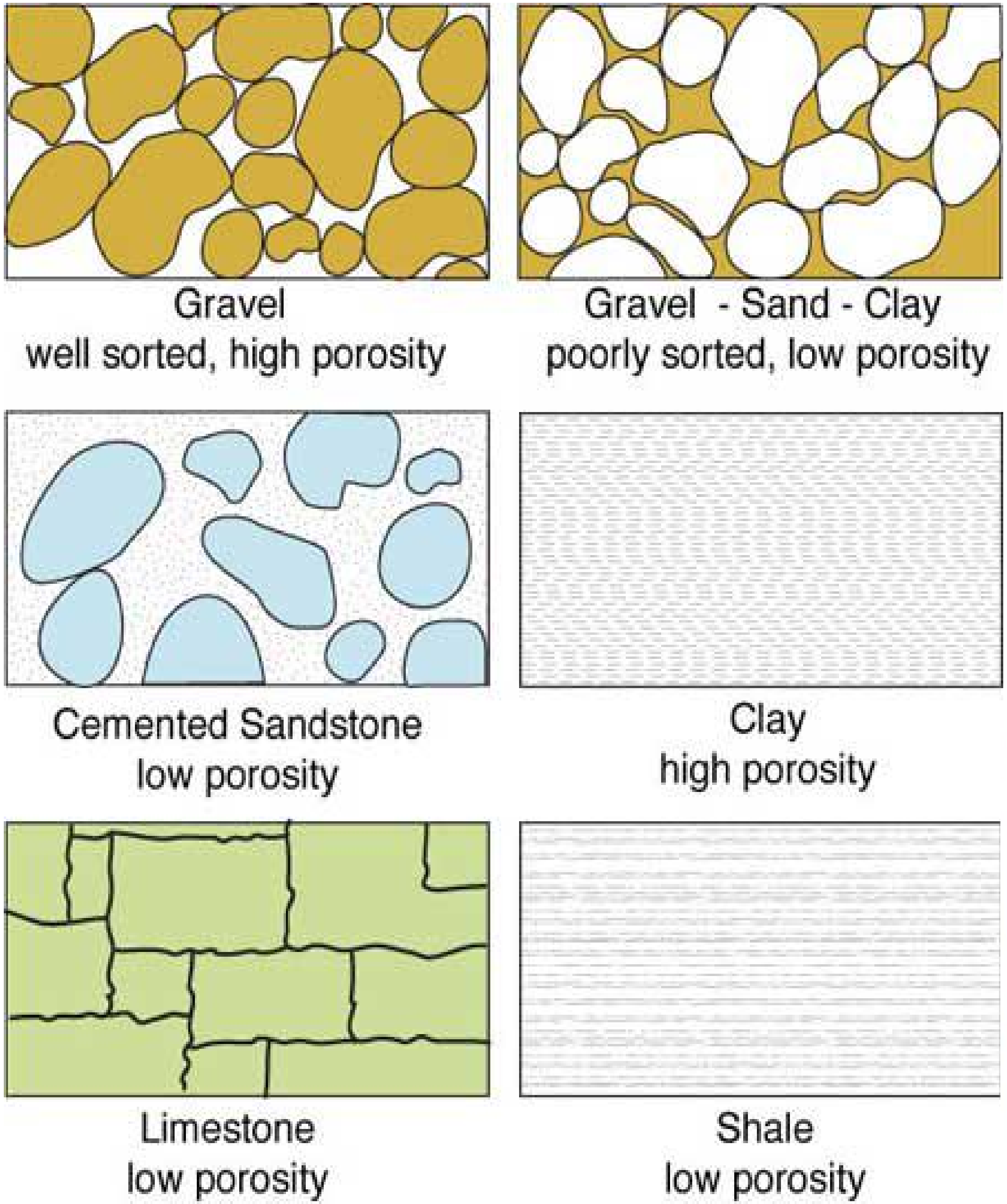
- Some pores are original void space in sedimentary rocks or vesicles in igneous rocks, which form as gases escape during cooling of magma-such a porosity is called **primary porosity**, because it forms at the same time as the rock itself forms.
- In sediments compacted and cemented to form sedimentary rocks, the precipitation of minerals and cementing material reduces the primary porosity.

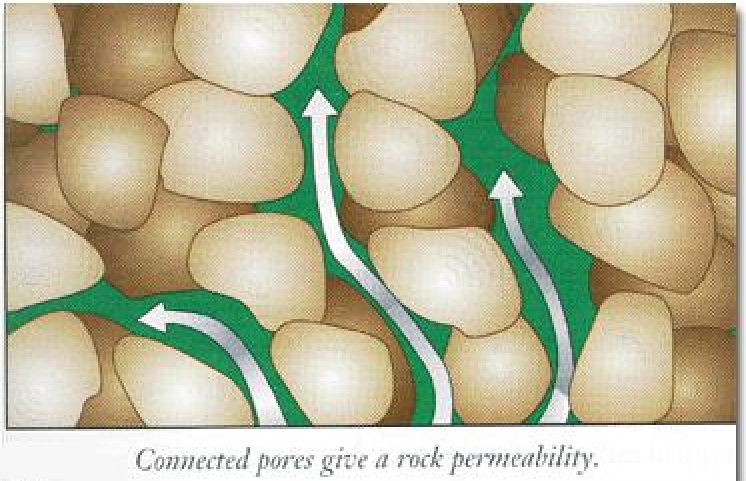
- Secondary porosity: a porosity caused by fractures caused by tectonism, uplift and erosion
- Generally primary porosity is the highest in sediments and sedimentary rocks and lower in unweathered crystalline igneous and metamorphic rocks.
- Primary porosity is higher in volcanic rocks than in plutonic rocks(some volcanic rocks form lava tube, gas escape vesicles, cracks).

➢ **Permeability:** the interconnectedness of pore spaces and the capacity of geologic material to allow fluids inside the earth. A highly porous rock/material like clay can hold huge water compared to its total volume but, it may not transmit enough water because individual pore spaces are isolated/poorly interconnected.

Figure 2. porosity in various geologc materials.

- Compare the rate of contaminant dispersion through the various geologic medium. (consider the porosity and permeability factors)





permeability

- The higher the specific retention, the harder to extract every bit of a contaminant from a groundwater by flushing and pumping the contaminated area.

- **Specific yield**: the amount of water that can be drained from a porous rock or sediment (ratio of water drained/total groundwater). Specific yield is always less than the porosity because some amount of water is held by surface tension, not possible to extract.
- **Specific retention**: Ratio of amount of groundwater retained by surface tension to the total groundwater .

6.4. Conflict on water resources

- With the ever increasing population on this planet the resources we have will become more strained. Many resource-based conflicts have been focused on oil and other technologically - replaceable resources. However, water is a basic resource that is necessary for the production of both fuel and food. It is used for waste disposal, industrial practices, and transportation.

The Nature of Water Resource Conflict

- Our sources of fresh water are not contained in the political boundaries that we have created, they naturally flow as the landscape dictates. Some regions of the world have water to waste, where others depend on every last drop. Water is hard to distribute from of plenty to those of scarcity. However in both regions of water wealth and water scarcity, conflict may arise when two or more nations compete for a water body's limited supply.

- As countries progress technologically, the amount of water that is desired and used by its population increases (Gleick, 1993). At some point these countries will reach the limit of their resources and it is possible that the limit of their industrial development will also be reached. The factors which determine the speed at which these boundaries are reached include the absolute availability of water, the level of development desired, and the population supplied.
- In addition, the quality of the water available is another factor that must be addressed when considering water availability. Water is worthless if its quality makes it unusable. Water must be available in sufficient quantities and quality levels.

- Once a water resource conflict arises, it may be based on the actual water body, i.e. the amount of water that is present, and/or the effects from water development projects, such as dams and reservoirs.
- When the concern is about the amount of water present, there are several factors that may lead to water resource competition. These include the degree of scarcity of water, the extent the water supply is shared among countries, the relative power of each of the states, and the accessibility of alternate fresh water supplies.
- Conflicts may also arise from the construction of a dam or reservoirs. Major development projects greatly alter the hydrologic and ecological attributes of a water body system, and may displace large populations and change the way local resources are accessible.

- International Water Resources Conflicts will occur in future because clean water resources are limited and use is increasing. Additionally, rivers flow across political boundaries man has made. International river and lake basins cover almost 50% of the world's continental land area

Example: The Nile hydro politics…water as a source of environmental conflict

- The Nile River is subject to political interactions. It is the world's longest river flowing 6,700 kilometers through ten countries in northeastern Africa – Rwanda, Burundi, Democratic Republic of the Congo (DRC), Tanzania, Kenya, Uganda, Ethiopia, Eritrea, Sudan and Egypt with varying climates. Considering the basin area of the Nile, Sudan has the largest size (1.9 million km^2) whereas, of the four major tributaries to the Nile, three originate from Ethiopia - the Blue Nile, Sobat and Atbara. The modern history of hydropolitics in the Nile basin is very complex and has had wide consequence both for regional and global developments

- An estimated **123 million people** depend on the Nile river for survival
- **85 %** of the Nile river water originates from **Ethiopia**, where as about **94 %** of the water is used by **Egypt** and **Sudan**.
- For several years there have been tensions among nations through which the Nile runs. However, nowadays tensions are **increasing due to the population growth, poverty, degradation of the ecosystem and water** scarcity that characterized the region.
- There has been increasing tension between the Nile basin countries in the past, especially between Egypt, Ethiopia and Sudan.
- At the heart of the tensions are the **1929** and **1959** Nile Water Agreements. Through these agreements Egypt assured that the Nile waters could not be interrupted by any circumstances by the rest of the basin countries, the agreements also prohibited any construction on tributaries that would interrupt the flow of Nile to Egypt and Sudan.

- There has been no conflict between countries until now; and in recent yeas, countries negotiated to use the Nile water equitably and established a transitional cooperation mechanism namely Nile Basin Initiative (**NBI**)

6.5. Groundwater as environmental, social and economic good

- The idea of treating water as an economic good has wide support.
- But the role of water as a basic need, a merit good, and a social, economic, financial, and environmental resource makes the selection of an appropriate set of prices exceptionally difficult.
- There is an emerging consensus that effective water resources management includes the management of water as an economic resource

- Is economic value measured by market price? If an item has a price of ETB X, is this also the amount of its economic value?
- Most people assume the answer is yes
- If it were true that **economic** value is **measured** by **market price**, this would imply that only **marketed commodities** can have an economic value. Items that are **not sold in a market** including the **natural environment**, generally -would have no economic value.
- If this were so, economic value would indeed be a narrow concept and at variance with many people's perspective sense of what is valuable.

Economic value is different than **price**. Price does not in general measure economic value, and items with no market price can still have a positive economic value**.**

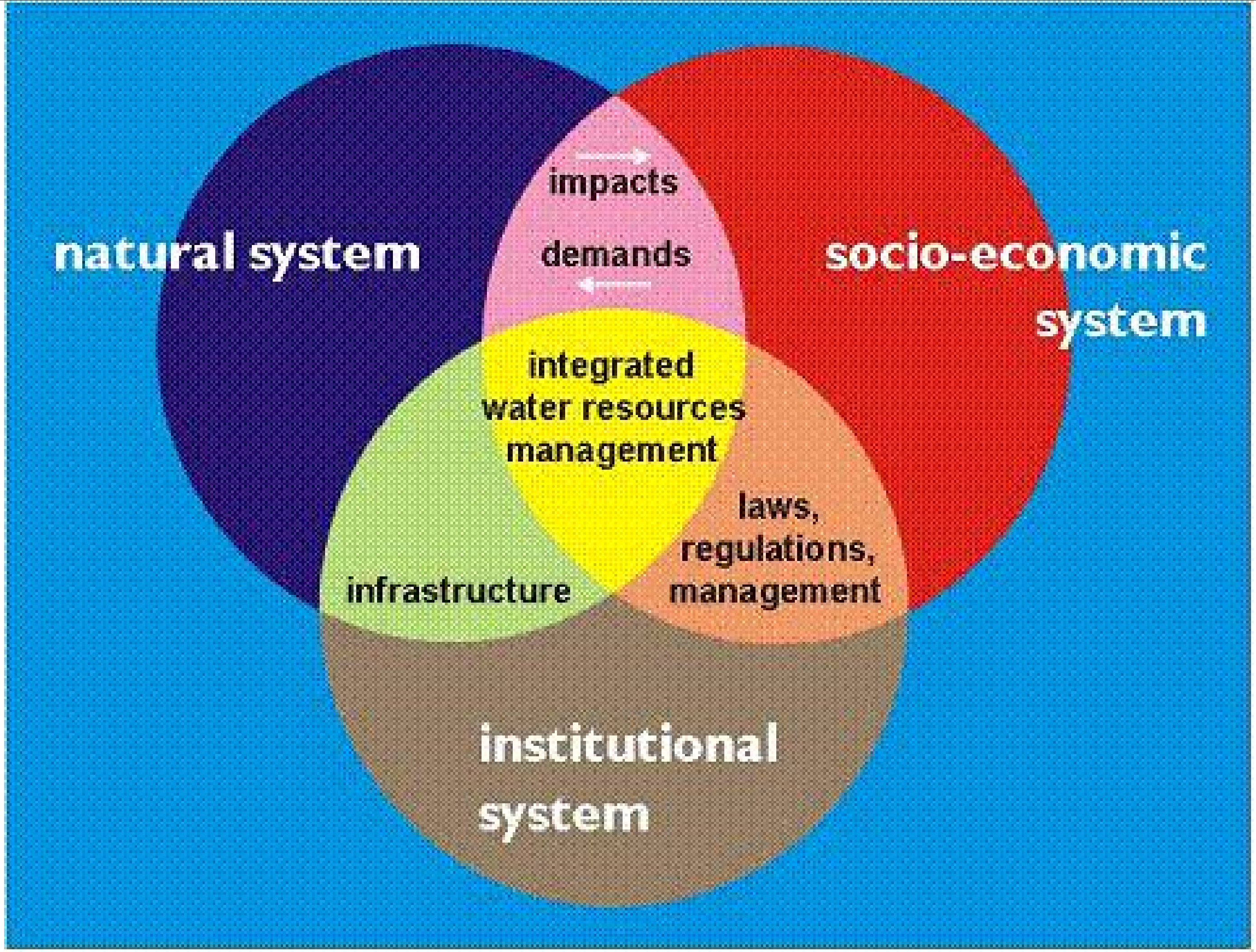
Water as a social good

- Water is both a *private* and *public* good!
- E.g. the water that you use at home, in a factory or in your farm is a private good, while water insitu can be used for public transport, recreation…
- flowing waters are treated as **common to everyone**, and are **not capable of being owned**. These waters can only be the object of rights of use, but **not of rights of ownership**. Thus, even though water and law are often complementary inputs, there is a crucial distinction in that land can be owned, while water cannot.

6.6. Concepts of integrated water resources management (IWRM)

- Integrated water resources management is the practice of making decisions and taking actions while considering multiple viewpoints of how water should be managed.
- These decisions and actions relate to situations such as river basin planning, organization of task forces , planning of new capital facilities, controlling reservoir releases, regulating floodplains and developing new laws and regulations.
- Integrated water resources management begins with the term "water resources management" itself, which uses structural measures and nonstructural measures to control natural and human-made water resources systems for beneficial uses

- Integrated Water Resources Management (IWRM) is "a process which promotes the coordinated **development** and **management** of ***water***, ***land*** and ***related resources***, in order to maximize the resultant **economic** and **social** welfare in an equitable manner without compromising the sustainability of vital **ecosystems**." Operationally, IWRM approaches involve applying knowledge from various disciplines as well as the insights from diverse stakeholders to devise and implement efficient, equitable and sustainable solutions to water and development problems. As such, IWRM is a comprehensive, participatory planning and implementation tool for managing and developing **water resources** in a way that ***balances social*** and ***economic*** needs, and that ensures the protection of ***ecosystems*** for future generations.



The basis for the methodology of IWRM is formed by the integrated analysis of three related entities in the Water Resources System: the Natural System, the Socio-economic System and the Institutional System and their interfaces

6.7. Human impact on groundwater

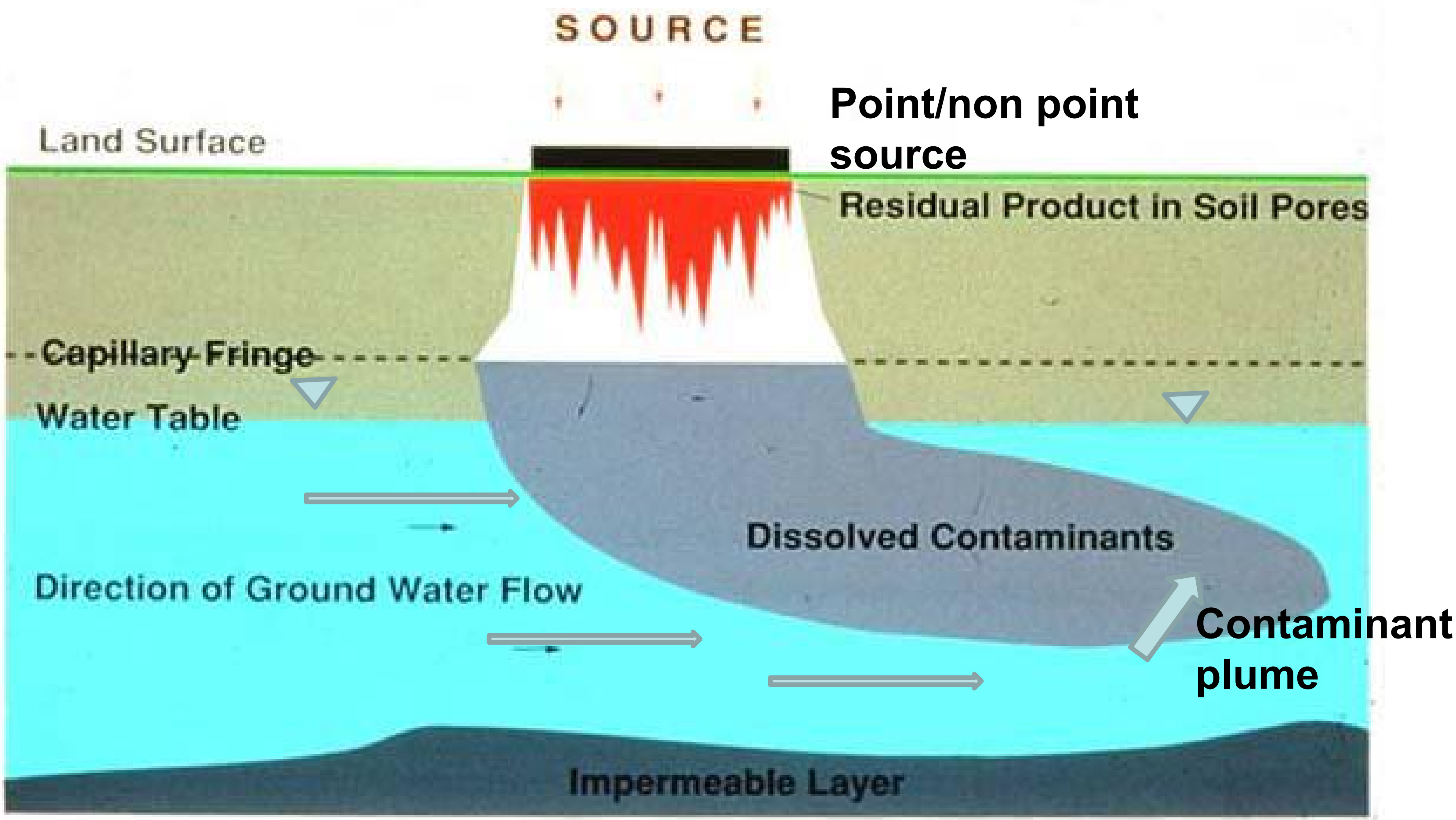
Groundwater pollution and its clean up

- Groundwater can be contaminated by biological pollutants, such as bacteria, protozoa, and by industrial chemicals such as tricholoroethene (TCE)
- Since the industrial revolution, contamination of groundwater by chemical pollutants is the greatest threat to drinking water.
- Surface water is more susceptible to biological pollution than groundwater, because many pathogens are similar in size to grains of silt and sand and thus can be trapped in the pore spaces in the aquifer or in the unsaturated zone above the groundwater table.

Migration of groundwater pollutants

- Substances carried by groundwater move at a rate that vary with molecular size, solubility of the substances, chemical activity, density and viscosity. E.g. when oil seeps underground, it floats at the water table, and move along the direction of the groundwater flow, giving off petroleum vapor and contaminating wells.
- **Miscible contaminants** flow in the groundwater as dissolved constituents (e.g. salt). They are initially diluted by streams and rivers, but in the groundwater, they tend spread out in long plumes through the process of **dispersion**.
- **Immiscible contaminants** are insoluble, and their fate in groundwater depends partly on their density. Those less dancer than water float above the groundwater table and flow down the hydraulic gradient(flow direction). E.g. gasoline. Denser immiscible contaminants sink down below the groundwater table e.g. TCE

Fig: Migration of groundwater pollutants (dispersion)



Groundwater restoration/clean up

- Groundwater treatment is a difficult and costly task! For the following reasons
  - Difficult to **detect** and **locate** groundwater pollution
  - **Long-term residency** of groundwater
  - **Once** an aquifer is **polluted**, **it** will **degrade**
  - It is a very **difficult** and **expensive practice**

- **Best practice** is to **prevent** any pollutant from interning the groundwater!

Chapter 7: Mineral and Energy Resources and Their Link to the Environment

7.1. Types of Mining

- What is mining?
- Mining is the process by which commercially valuable mineral resources are extracted (removed) from Earth's surface/subsurface.
- These resources include ores (minerals usually containing metal elements),
- precious stones (such as diamonds),
- building stones (such as granite), and
- solid fuels (such as coal).
- Although many specific kinds of mining operations have been developed, they can all be classified into one of two major categories: surface and subsurface (or underground) mining.

Some terminologies

- **Adit**: A horizontal tunnel constructed to gain access to underground mineral deposits.
- **Metallurgy**: Science and technology of extracting metals from their ores and refining them for use.
- **Ore**: A mineral compound that is mined for one of the elements it contains, usually a metal element.
- **Overburden**: Rocky material that must be removed in order to gain access to an ore or coal bed.
- **Prospecting**: The act of exploring an area in search of mineral deposits or oil.
- **Shaft**: A vertical tunnel constructed to gain access to underground mineral deposits.

two major categories of mining: surface and subsurface (or underground) mining

A. Surface mining

- When an ore bed has been located relatively close to Earth's surface, it can be mined by surface techniques. Surface mining is generally a much preferred approach to mining because it is less expensive and safer than subsurface mining

- Surface mining can be subdivided into two large categories: (1) **open-pit mining** and (2) **strip mining.**

1. **Open-pit mining** is used when an ore bed covers a very large area in both distance and depth. Mining begins when scrapers remove any non-ore material (called overburden) on top of the ore. Explosives are then used to blast apart the ore bed itself. Fragments from the blasting are hauled away in large trucks. As workers dig downward into the ore bed, they also expand the circular area in which they work. Over time, the open-pit mine develops the shape of a huge bowl with terraces or ledges running around its inside edge. Open-pit mining continues until the richest part of the ore bed has been excavated.

2. strip mining

- When an ore bed covers a wide area but is not very deep, strip mining is used. It begins the same as open-pit mining, with scrapers and other machines removing any overburden. This step involves the removal of two long parallel rows of material. As the second row is dug, the overburden removed is dumped into the first row. The ore exposed in the second row is then extracted. When that step has been completed, machines remove the overburden from a third parallel row, dumping the material extracted into the second row. This process continues until all the ore has been removed from the area. Afterward, the land typically resembles a washboard with parallel rows of hills and valleys consisting of excavated soil.

B. Subsurface mining

- Ores and other mineral resources may often lie hundreds or thousands of feet beneath Earth's surface. Because of this, their extraction is difficult. To gain access to these resources, miners create either a horizontal tunnel (an **adit**) or a vertical tunnel (a **shaft**). To ensure the safety of workers, these tunnels must be reinforced with wooden timbers and ceilings. In addition, ventilation shafts must be provided to allow workers a sufficient supply of air, which is otherwise totally absent within the mine.

- Once all safety procedures have been completed, the actual mining process begins. In many cases, the first step is to blast apart a portion of the ore deposit with explosives. The broken pieces obtained are then collected in carts or railroad cars and taken to the mine opening.

- Other techniques for the mining of subsurface resources are also available. The removal of oil and natural gas by drilling into Earth's surface are well-known examples. Certain water-soluble minerals can be removed by dissolving them with hot water that is piped into the ground under pressure. The dissolved minerals are then carried to the surface. E.g. salt and sulfur minerals

➢ Which one of the mining step cause the highest damage to the environment?

7.2. General Environmental impacts of mining

- Extracting and using mineral resources can disturb the land, erode soils, produce large amounts of solid waste, and pollute the air, water, and soil.
- High energy use
- Disturb land
- Erode soil
- Produce solid waste (gangue)

The environmental impact of a mining activity…in detail

- The environmental impact of a mining activity depends on many factors like

-mining procedures/type of mining activity

-local hydrologic conditions

-climate

-rock type

-size of mining operations

-topography

Many more other interrelated factors

Mining activities have adverse effect on land, water, air and biological resources.

Environmental Impacts Unique to each surface Mining

- **Open pit mining:** Effect on the environment caused by open pit mines

- the removal of huge chunks of land (overburden), creating craters.
- In addition to being a huge eyesore (bad for scenery),
- Habitat destruction for organisms in the area
- A link in the ecosystem chain is chopped out,
- The entire biodiversity of the area suffers.
- Also, when the mine is no longer in operation, the area can no longer be used for anything else.

➢ **Strip mining**

- Strip mining, most commonly used to mine **coal**,
- Main environmental effects unique to coal mining are the methane gasses released (causing a greenhouse effect),
- Effects on water, and the dust produced.
- extremely harmful to the environment due to its massive amount of emissions.
- Gasses released by coal mining, primarily methane, are among the leading contributors to global warming and climate change in general.
- Huge deforestation due to **mountain top strip coal mining**
-

- drastically alters the landscape (strip mining involves removing large strips of land [overburden] to expose minerals underneath).
- further harmed the environment when it is burned as a fuel, which creates toxic fumes.

mountain top strip coal mining

7.3. Direct environmental effects caused by mining

- ***Water pollution***:

- Surface drainage altered at mine sites, and it often infiltrate through mine waste materials leaching out trace elements and metals toxic to the environment.
- Trace metals leached from mine waste and concentrated in water, soil or plants may be toxic causing disease I people and other animals who drink the water, eat the plants and or use the soil.
- Potentially harmful trace elements are: cadmium, cobalt, copper, lead, molybdenum, and zinc.
- Polluted surface water infiltrating in to the ground cause groundwater pollution. Sulphide mineral wastes may cause the water to be acidic/sulfuric acid.

- **Acid mine drainage** is the formation and movement of highly acidic water rich in heavy metals. This acidic water forms through the chemical reaction of surface water (rainwater, snowmelt, pond water) and shallow subsurface water with rocks that contain sulfur-bearing minerals, resulting in sulfuric acid. Heavy metals can be leached from rocks that come in contact with the acid, a process that may be substantially enhanced by bacterial action. The resulting fluids may be highly toxic and, when mixed with groundwater, surface water and soil, may have harmful effects on humans, animals and plants.

- The major metallic sulfide of concern is iron sulfide (FeS_2) or pyrite. Other metal sulfides that contribute to acid generation include lead sulfide (galena), zinc sulfide (sphalerite), and iron copper sulfide (chalcopyrite).
- During acid generation, the pH values of the associated waters typically decrease to values near 2.5. These conditions result in the dissolution of the minerals associated with the metallic sulfides and release of toxic metal cations (e.g., lead, copper, silver, manganese, cadmium, iron, and zinc). In addition, the concentration of dissolved anions (e.g., sulfate) also increases.

Cyanide and Other Chemical Releases

- The mining industry has a long history of cyanide use. For decades, cyanide has been used as a pyrite depressant in base metal flotation. It has also been used for over a century for gold extraction. After cyanide leaching of gold heaps proved feasible in the 1970s, the relatively high price of gold has made cyanide leaching of relatively low-grade ores economically feasible
- Cyanide exists in many forms, depending on the starting compound and environmental conditions. The most common cyanide compound used in mining is sodium cyanide (NaCN).
- Cyanide released into the environment can adversely impact water, soil, aquatic organisms, wildlife, waterfowl, and humans. Cyanide-contaminated solution in tailing ponds and solution retention basins has proven to be attractive to unsuspecting waterfowl and wildlife. These organisms have suffered both acute and chronic poisoning as a result of direct contact with and ingestion of cyanide-contaminated solution.

➢ *Air pollution*

- Both extraction and processing of minerals has adverse effects on air quality.
- Mine dust from explosives, mine roads pollutes the air
- Abandoned mine sites, like abandoned coal mines release gases like methane, that cause air pollution.
- Mineral processing like smelting(melting of metal containing ores to extract metals) causes severe air pollution. Release of sulfide oxide gases causes acid rain.

Air pollution

-Human contamination of Earth's atmosphere can take many forms and has existed since humans first began to use fire for agriculture, heating, and cooking.

- During the Industrial Revolution of the 18th and 19th centuries, however, air pollution became a major problem.

-Urban air pollution is commonly known as **smog**.

-As the smog ages and reacts with oxygen, organic and sulfuric acids condense as droplets, increasing the haze.

- Smog developed into a major health hazard by the 20th century.

-In 1948, 19 people died and thousands were sickened by smog in the small U.S. steel-mill town of Donora, Pennsylvania.

-In 1952, about 4,000 Londoners died of its effects.

- A second type of smog, ***photochemical smog***, began reducing air quality over large cities like Los Angeles in the 1930s.

-This smog is caused by combustion in car, truck, and airplane engines, which produce *nitrogen oxides* and release *hydrocarbons* from unburned fuels.

- Sunlight causes the nitrogen oxides and hydrocarbons to combine and ***turn oxygen into ozone***, a chemical agent that attacks rubber, injures plants, and irritates lungs.

- The hydrocarbons are oxidized into materials that condense and form a visible, ***pungent haze***.

- Eventually most pollutants are washed out of the air by rain, snow, fog, or mist, but only after traveling large distances, sometimes across continents.

-As pollutants build up in the atmosphere, *sulfur* and *nitrogen* oxides are converted into *acids* that mix with rain.

-This **acid rain** falls in lakes and on forests, where it can lead to the death of fish and plants, and damage entire ecosystems.

- Eventually the contaminated lakes and forests may become lifeless.

- Regions that are downwind of heavily industrialized areas, such as Europe and the eastern United States and Canada, are the hardest hit by acid rain.

- Acid rain can also affect human health and man-made objects; it is slowly dissolving historic stone statues and building facades in London, Athens, and Rome.

-One of the greatest challenges caused by air pollution is **global warming**, an increase in Earth's temperature due to the buildup of certain atmospheric gases such as carbon dioxide.

- With the heavy use of fossil fuels in the 20th century, atmospheric concentrations of carbon dioxide have risen dramatically.

- Carbon dioxide and other gases, known as **greenhouse gases**, reduce the escape of heat from the planet without blocking radiation coming from the Sun.

- Because of this greenhouse effect, average global temperatures are expected to rise 1.4 to 5.8 Celsius degrees (2.5 to 10.4 Fahrenheit degrees) by the year 2100.

- Although this trend appears to be a small change, the increase would make the Earth warmer than it has been in the last 125,000 years, possibly changing climate patterns, affecting crop production, disrupting wildlife distributions, and raising the sea level by melting of Ice sheets.

-Air pollution can also damage the upper atmospheric region known as the **stratosphere** where there is the ozone layer.

- Excessive production of chlorine-containing compounds such as chlorofluorocarbons (**CFCs**) (compounds formerly used in refrigerators, air conditioners, and in the manufacture of polystyrene products) has depleted the stratospheric **ozone layer**, creating a hole above Antarctica that lasts for several weeks each year.

- As a result, exposure to the Sun's harmful rays has damaged aquatic and terrestrial wildlife and threatens human health in high-latitude regions of the northern and southern hemispheres.

➢Impact on biological environment/health impacts

- Direct impacts: death of plants and animals, and or people caused by mining activity or contact with toxic soil or waste from mines

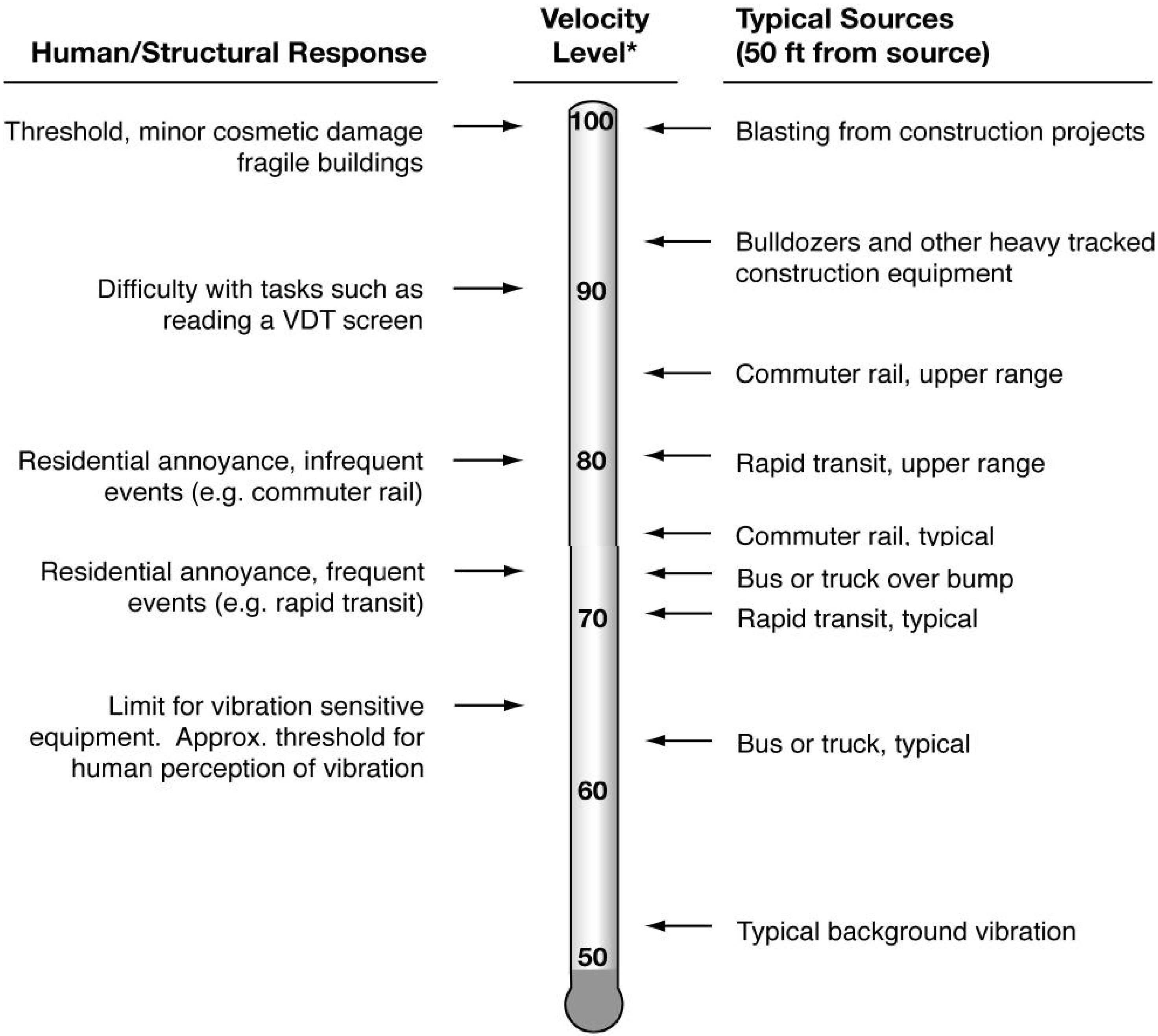
E.g. **Itai-itai disease (itai-itai)** "ouch-ouch.“ in Japanese

- Itai-itai disease was found in the cadmium(Cd) polluted Jinzu River basin in Toyama Prefecture, and has been generally recognized since the 1950's. The disease is characterized initially by complaints of spinal and leg bone pain, and deformation.
- One of the main effects of cadmium poisoning is weak and brittle bones. Spinal and leg pain is common, and a waddling gait often develops due to bone deformities caused by the cadmium.

➢ *Noise Pollution*

-Unwanted sound, or noise, such as that produced by airplanes, traffic, or industrial machinery, is considered a form of pollution.

- Noise pollution is at its worst in densely populated areas.
- It can cause hearing loss, stress, high blood pressure, sleep loss, distraction, and lost productivity.
- Sounds are produced by objects that vibrate at a rate that the ear can detect.
- Most humans can hear sounds between 20 and 20,000 hertz, while dogs can hear high-pitched sounds up to 50,000 hertz.
- While high-frequency sounds tend to be more hazardous and more annoying to hearing than low-frequency sounds, most noise pollution damage is related to the intensity of the sound, or the amount of energy it has.
- Measured in decibels, noise intensity can range from zero, the quietest sound the human ear can detect, to over 160 decibels.



** RMS Vibration Velocity Level in VdB relative to 10^{-6} inches/second*

-Conversation takes place at around 40 decibels, a subway train is about 80 decibels, and a rock concert is from 80 to 100 decibels.

- The intensity of a nearby jet taking off is about 110 decibels. The threshold for pain, tissue damage, and potential hearing loss in humans is 120 decibels.

-Long-lasting, high-intensity sounds are the most damaging to hearing and produce the most stress in humans.

- Solutions to noise pollution include adding insulation and sound-proofing to doors, walls, and ceilings; using ear protection, particularly in industrial working areas; planting vegetation to absorb and screen out noise pollution; and zoning urban areas to maintain a separation between residential areas and zones of excessive noise.

➢ *Thermal Pollution*

-harmful increase in water temperature in streams, rivers, lakes, or occasionally, coastal ocean waters.

- Thermal pollution is caused by either dumping hot water from factories and power plants or removing trees and vegetation that shade streams, permitting sunlight to raise the temperature of these waters.

- Like other forms of water pollution, thermal pollution is widespread, affecting many lakes and vast numbers of streams and rivers in the United States and other parts of the world.

- A temperature increase as small as 1 or 2 Celsius degrees (about 2 to 4 Fahrenheit degrees) can kill native fish, shellfish, and plants, or drive them out in favor of other species, often with undesirable effects.

-In general, cold waters are better habitat for plants and animals than warm ones because cold waters contain *more dissolved oxygen*

Thermal Pollution from Power Plants and Factories

Power plants and industrial factories are among the major contributors to the problem of thermal pollution. These facilities draw water from nearby lakes and streams, which they use to cool their machinery and **steam-driven equipment**.

Although many such facilities now take care not to contaminate the water with chemical pollutants, few return the heated water to its original temperature before dumping it back into the lakes and streams from which it came. The heated water warms local bodies of water by as much as 10° C (18° F), making the water uninhabitable for fish and other organisms.

Environmental Effects of Using Mineral Resources

- Disruption of land surface
- Subsidence
- Erosion of solid mining waste
- Acid mine drainage
- Air pollution
- Storage and leakage of liquid mining waste

- **Final remark**: try to see the environmental effects of mining at the 3 stages

1. During extraction (actual mining)
2. Processing (separation of minerals from gangue/wastes)
3. Usage of minerals

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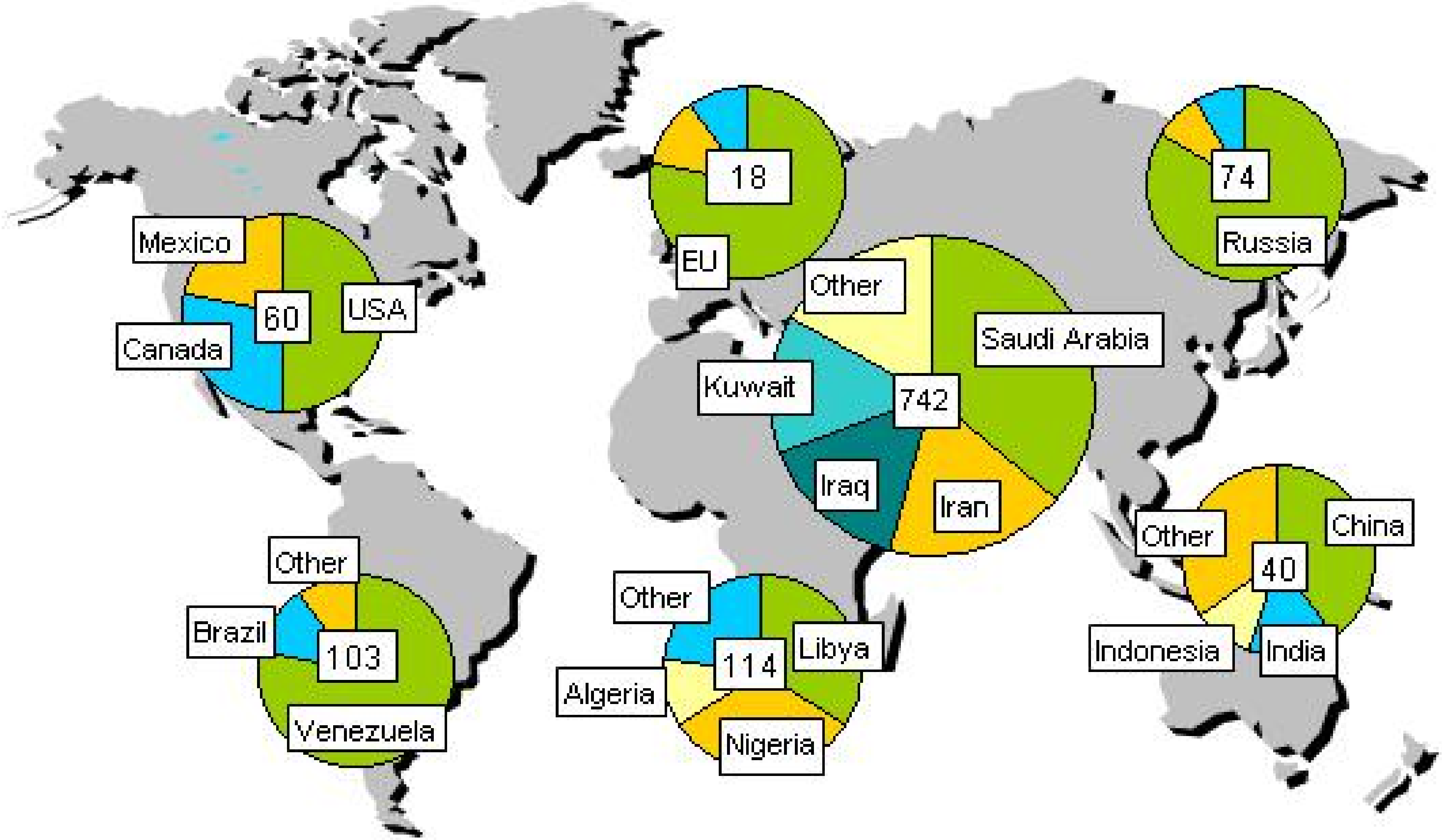
7.4. Fossil Fuels and environmen

- oil, called crude oil, and natural gas are hydrocarbons made of carbon and hydrogen mainly and oxygen. Similarly to coal, hydrocarbons are fossil fuels in that they form from organic material that escaped complete decomposition after burial.
- Next to water, oil is the most abundant fluid in earths crust.
- About 40% of the total energy consumed in the entire world is now contributed by oil. Saudi Arabia oil producing has ¼th of the world oil reserves.



- World petroleum resource distribution. Note. The pie charts for each major location show the estimated proved reserve volume in billion bbls, and the proportion for the main countries is shown in the pie segments. Source: BP (2006)

- Natural gas mainly consists of Methane (CH_4) along with other inflammable gases like Ethane and propane. Natural gas contains less carbon and more hydrogen than does oil, making it less dense and cause relatively less environmental damage compared to oil and coal.

Environmental impacts of using fossil fuel

- ***Ash particles***

Ash particles are the unburnt fuel particle. Petro and natural gas generate less ash particles than coal, diesel or gasoline. They may cause lung problem

- ***Acid rain***

When fossil fuels are buried, Sulphur, Nitrogen and Carbon combine with oxygen to form toxic compounds. These oxides when released into the atmosphere, they react with water form and result in the formation of Sulfuric acid, Nitric acid and Carbonic acid. This leads to acid rain

- ***Global warming***

Carbon dioxide is a major by product of fossil combustion and this gas is known as green hour gas. Green house gas absorbs solar heat reflected off the earth's surface and retains this heat, keeping the Earth warm and habitats for living organisms.

Rapid industrialization between 19th and 20th centuries however has resulted in increasing fossils fuel emissions, raining the percentage of carbon dioxide by about 28%. This drastic increase has led to global warming that could cause environmental problems, including disrupted weather patterns and polar ice cap melting.

- ***Ocean pollution/Oil Spills***

Mostly from ships that flush their oil tanks at sea and from industrial and urban runoff from continents.

- Sometimes from large accidental oil spills from tankers transporting oil across the oceans.

7.5. Alternative energy resources

- An energy source that can be used instead of fossil fuels
- It is usually a renewable source of energy that could be used should fossil fuels run out

Why is there a need for alternative sources of energy?

- ✓ The graph (that you have seen in chapter 1) last time shows just how much we rely on fossil fuels
- ✓ 90 per cent of the worlds energy supply's come from fossil fuels
- ✓ Burning fossil fuels has increased atmospheric pollution, acid rain, carbon released from fossil fuels is causing global warming

8. Geology and Health

- Linkage between health and geo-environmental setting
- Trace elements in human and animal health

- Medical Geology is an emerging scientific discipline that examines the impacts that geologic materials and processes have on human and ecosystem health.

Medical Geology:

- Identifies and characterizes natural and anthropogenic sources of harmful materials in the environment.
- Predicts the movement and alteration of chemical, infectious, and other disease- causing agents over time and space.
- Provides an understanding of how people are exposed to harmful materials and
- describes what can be done to minimize or prevent such exposure.
- "the science dealing with the influence of ordinary environmental factors on the geographical distribution of health problems in man and animals."

- We Are What We Eat and Drink
- On our planet, the chemical elements flow through the different planetary compartments, including the atmosphere, hydrosphere, lithosphere, and biosphere. Humans and animals are part of these cycles. The chemical elements pass into and out of them, too, in a complex biogeochemical cycle.
- Obviously, then, the chemistry of any local geological environment must have a direct influence on the chemical make-up of those living there. This is most readily seen in places where humans live in particularly intimate contact with the local physical environment, as is the case with rural people living in tropical countries.

- “All substances are poisons; there is none which is not a poison. The right dosage differentiates a poison and a remedy.”Even water, when consumed too quickly and in excessive amounts, can be lethal.

If this is the case,

- One of the primary objectives of medical geologists, therefore, is to determine the optimal exposures for people to the essential elements in order to maintain or improve health.

8.1. Linkage between health and geo-environmental setting

- Man - like any other form of life - has adjusted through millions of years to chemical trace elements supplied by the soil. If the supply of certain trace elements is too large the result is poisoning if it is insufficient deficiency diseases occur. The existence or lack of a particular trace dement depends on the geochemical environment. Life, to no small degree , is influenced by what soil does or does not supply.

Even when there is plenty of food available essential trace elements may either be missing altogether or may occur in toxic concentration.

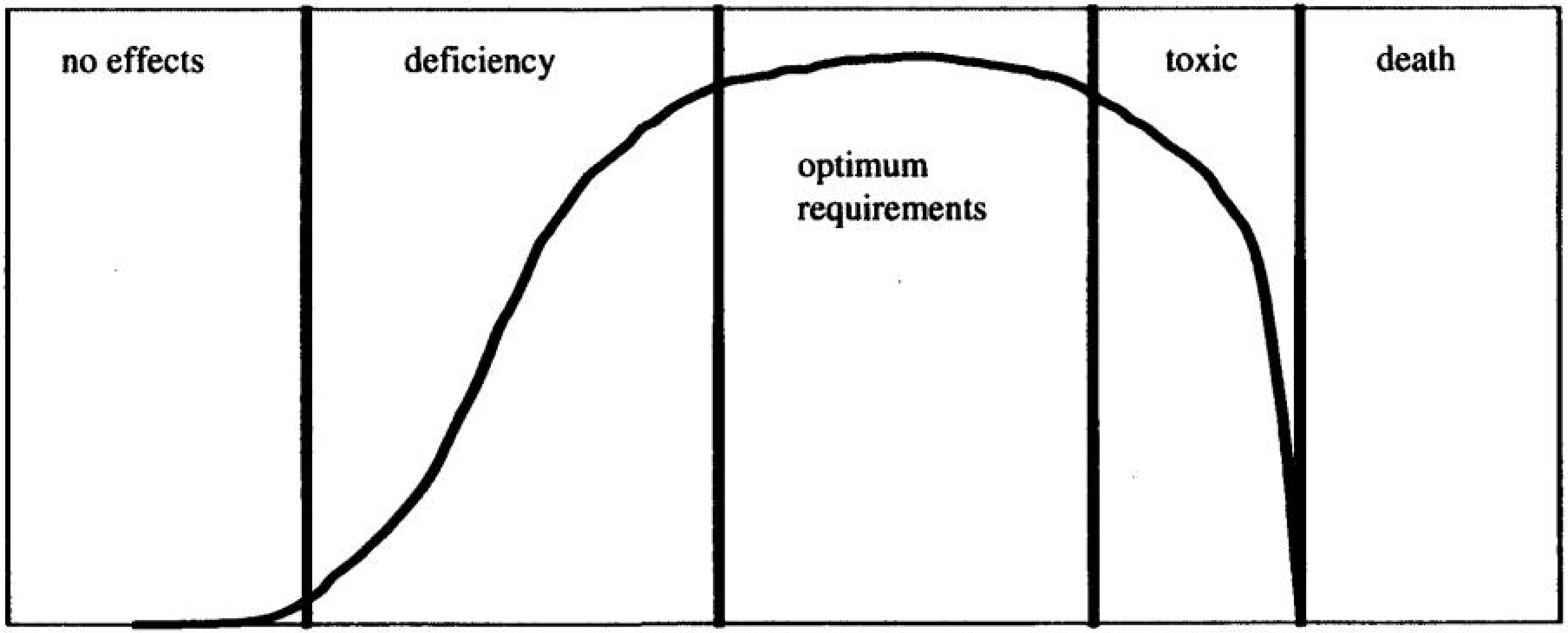


Fig.1: Physiological effects

Physiological effects of essential trace elements present in the geological media (soils, water, and plants) and their effects as they are consumed by man and animals in excess/in deficiency.

8.2. Trace elements in human and animal health

- Trace elements play an essential role in the normal metabolism and physiological functions of animals and humans.
- Some 22 such elements are known or thought to be "essential" for humans and other animals.
- "Macronutrients" are required in fairly large amounts (e.g. grams per kilogram of diet),whereas
- "micronutrients" are required in much smaller amounts (e.g. microgram-to-milligrams per kilogram of diet).

- Sixteen elements are established as being essential for good health. Calcium, phosphorus, magnesium,and fluoride for example, are required for structural functions in bone and membranes. Sodium, potassium,and chloride are required for the maintenance of water and electrolyte balance in cells. Zinc, copper, selenium, manganese, and molybdenum are essential constituents of enzymes or serve as carriers (iron) for ligands essential in metabolism.

- Chemical elements are also important in the functioning of the endocrine system.
- For instance, iodine is an essential component of the thyroid hormone thyroxine, and chromium is the central atom of the hormone-like glucose tolerance factor. Because these are all critical life functions, the tissue levels of many "nutritionally essential elements" tend to be regulated within certain ranges, and dependent on several physiological processes, especially homeostatic control of enteric absorption, tissue storage, and/or excretion.
- Changes in these physiological processes may worsen the effects of short-term dietary deficiencies or excess of trace elements.

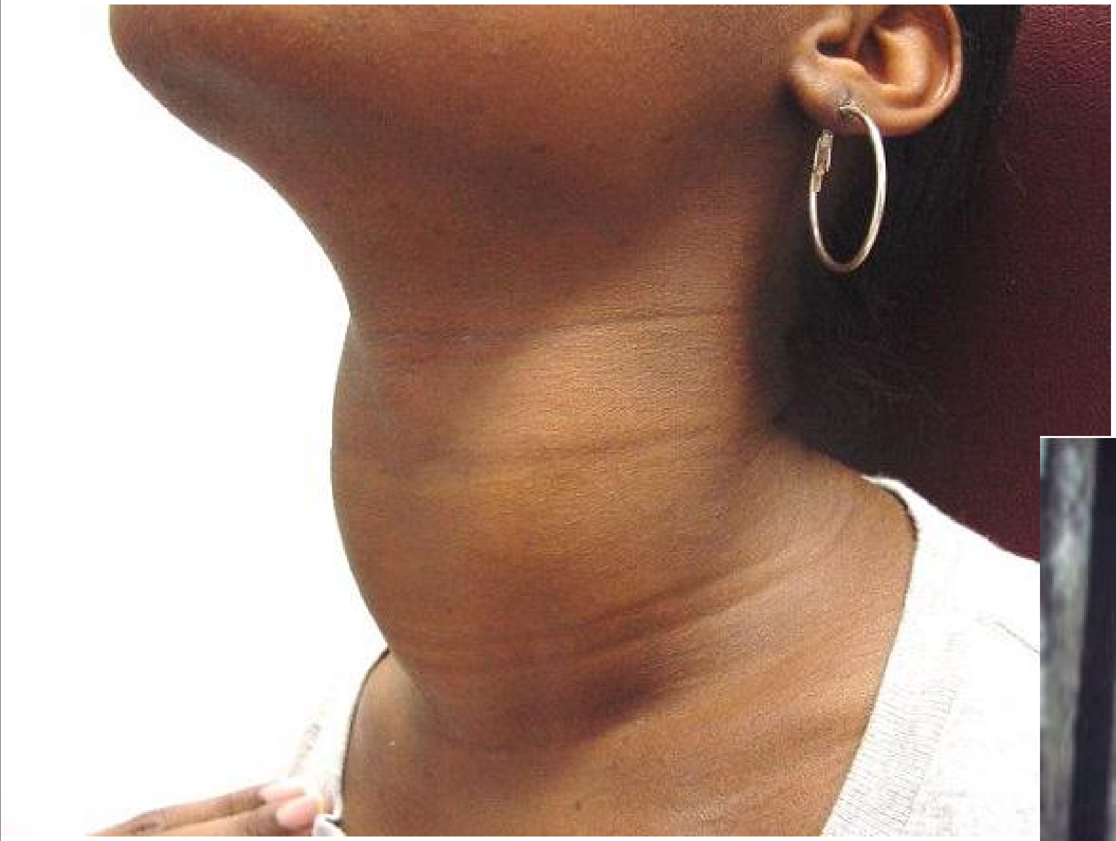
- Food is a major source of trace elements in humans and animals. However, other sources such as the delibe ate eating of soil (geophagia) and water supplies may also contribute to dietary intake of trace elements.
- Diseases due to trace element deficiencies as well as excesses are known for iodine,
- Copper(Cu)
- Zinc(Zn)
- Selenium(Ce)
- Molybdenum(Mo)
- Manganese(Mn)
- Iron(Fe)
- Calcium(Ca)
- Arsenic(As)
- Cadmium(Cd)

8.3. Some Diseases Due to Trace Element Deficiencies

Iodine

- Iodine Deficiency Disorders (IDD) include goiter (enlargement of the thyroid gland), cretinism (mental retardation with physical deformities), reduced IQ, miscarriages, and birth defects. In ancient China, Greece and Egypt as well as among the Incas, people affected by goiter, were given seaweed to provide the needed iodine
- In all the places where the risk of IDD is high, the content of iodine in drinking water is very low because of low concentrations of iodine in bedrock.

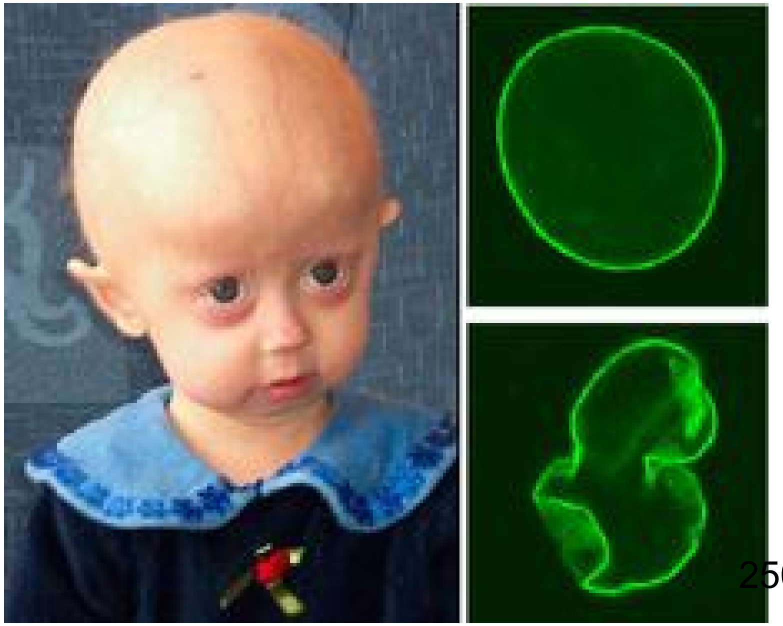
Fig. Iodine deficiency and Ce deficiency



Selenium

- Selenium is an essential trace element having antioxidant protective functions as well as redox and thyroid hormone regulation properties. However, selenium deficiency (due to soils low in selenium),has been shown to cause severe physiological impairment and organ damage such as a juvenile cardiomyopathy and muscular abnormalities in adults
- These diseases were always located in areas with low selenium soils

- The occurrence of low selenium is thought to contribute to other illnesses including impaired reproduction, various cancers, infectious diseases, and, due to its antioxidant properties, rapid aging.
- Also, metabolic selenium combined with other trace elements appears to promote good health. For example, the ratio of selenium to arsenic in the body can modulate the toxic effects of either element alone



8.4. Toxicity of Essential and Non-essential Elements

Arsenic

- Arsenic and arsenic compounds are human carcinogens. Exposure to arsenic may occur through several anthropogenic sources, including mining, pesticides, pharmaceuticals, glass and microelectronics, and most commonly, natural sources.
- Exposure to arsenic occurs via ingestion, inhalation, dermal contact and the parenteral route to some extent.
- Drinking water contaminated with arsenic is a major public health problem.

- General health effects associated with arsenic exposure include
- cardiovascular and peripheral vascular disease,
- developmental anomalies,
- neurologic and neurobehavioural disorders,
- diabetes,
- hearing loss,
- portal fibrosis,
- hematologic disorders (anemia, leukopenia and eosinophilia) and
- cancers.
- Significantly higher standardized mortality rates and cumulative mortality rates for cancers of the skin, lung, liver, urinary bladder, kidney, and colon occur in many areas polluted with arsenic

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- By studying the geological and hydrological environment, geoscientists are trying to determine the source rocks from which the arsenic is being leached into the ground water. They are also trying to determine the conditions under which the arsenic is being mobilized.
- Understanding the mechanisms by which arsenic is mobilized will permit the public health officials around the world to identify aquifers that may pose a threat to their communities.
- Source of arsenic: sulfide bearing minerals, groundwater, plants, coal,

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Fluorine

- Over-exposure to trace elements in geologic materials is responsible for toxicity effects in humans and animals. One of the most studied trace elements in this regard is fluorine
- The fluoride ion (F-) stimulates bone formation and also reduces dental caries at doses of at least 0.7 mg/L in drinking water. However, excess fluoride (>1 mg/L) exposure can cause fluorosis of the enamel (mottling of the teeth) and bone (skeletal fluorosis)

Radon

- Exposure to natural gases such as radon is potentially hazardous. Geologic materials are the most important factor controlling the source and distribution of radon. Relatively high levels of radon emissions are associated with specific types of bedrock and unconsolidated deposits, including some granites, phosphatic rocks, and shales rich in organic materials.
- The release of radon from rocks and soils is controlled largely by the types of minerals in which uranium and radium occur. Radon levels in outdoor air, indoor air, soil air, and ground water can be very different
- Radon that enters poorly ventilated buildings, caves, mines, and tunnels can reach dangerously high concentrations.

8.5. Health benefits of geologic materials

- Some of the earliest known medicines were derived from rocks and minerals. For thousands of years various clays were used as an antidote for poisons.
- Many trace elements, rocks, and minerals are used today in a wide variety of pharmaceuticals and health care products.
- Hot springs are in wide application to cure muscle and joint pains.

Chapter 9: Soils and Environment

- **Chapter content**
- Soils as regulators of global climate changes
- Formation and types of soils
- Soil Erosion and degradation
- Soil preservation approaches

Soils

- Sustain the terrestrial Biome
  - Supports plant growth
  - Filter or modify precipitation
  - Regulate amount of water entering ground.
  - Habitat for many organisms
  - ❑What is Soil?

  a dynamic natural body composed of mineral and organic materials and living forms in which plants grow.
- Unconsolidated natural materials on the earth surface that support rooted plant growth.

- Unconsolidated materials are produced by physical and chemical alteration of rocks (weathering) and mediated or modified by biotic processes.
  - What are some of the uses for soils?
    - Medium for plant growth
    - recycling of nutrients and wastes
    - water supply and purification
    - habitat for soil organisms
    - engineering medium
  - What is soil composed of?
    - mineral material (45%)
    - organic material (5%)
    - air (20-30%)
    - water (20-30%)

Formation and types of soils

Soil development is a function of Soil Forming Factors like

- climate
- organisms
- relief (topography)
- parent material
- time
- HUMANS

Soil = f (clorpth)

- Different combinations and intensities of the different soil forming factors create different soils!
- These differences are a result of processes affected by the soil forming factors that directly and indirectly affect the soil properties.
- SOIL PROFILE –HORIZONS
- Various soil forming processes lead to the formation of distinct layers - known as soil HORIZONS.
- The stacked layers produced a sequence that is typical of different types of soils - known as a soil PROFILE.

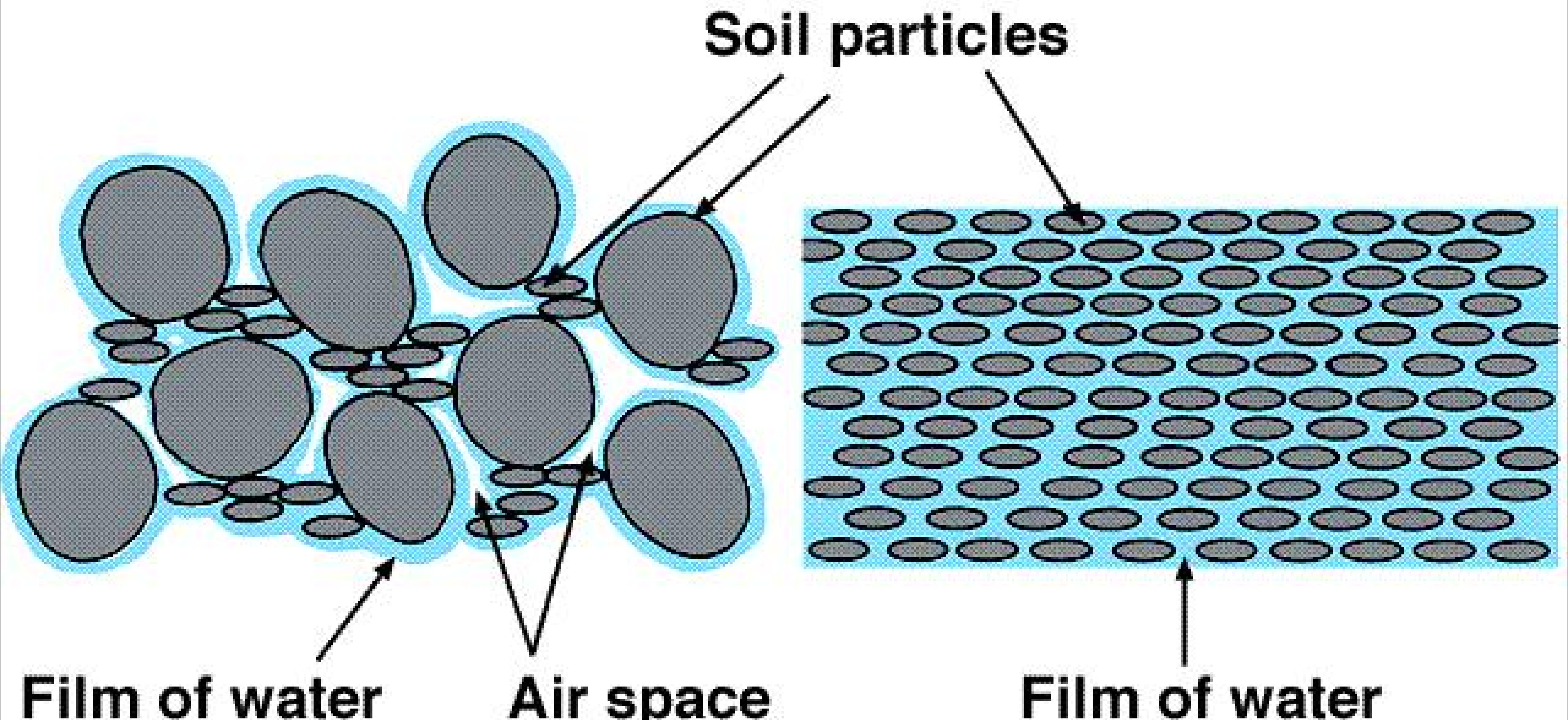
SOIL TEXTURE

- Refers to the characteristic look and feel resulting from the variable amounts of SAND - SILT - CLAY.
  - SAND: grains that are 2 to 0.05 mm in diameter
  - SILT: grains that are less than 0.05 mm and as small as 0.002 mm in diameter
  - CLAY: grains that are smaller than 0.002 mm in diameter.

SOIL PROPERTIES

- Water
  - Permeability: ability to allow water to pass through the pores (open space between grains). Depends greatly on texture. Infiltration is the actual water that passes through the soil.
  - Water-holding capacity: quantity of water that a soil can retain and is available for plant usage.
  - Evaporative water loss: amount of water lost from a soil surface to evaporation

Pore Spaces and Particle Size



SOIL PROPERTIES

- Nutrients
  - Mineral Nutrients: element or compounds derived from soil components and available for use by producers. Includes phosphate (PO4-3), potassium (K+), calcium (Ca++), and other.
  - Nutrient-holding capacity: quantity of mineral nutrients retained by the soil (on the surface of grains). Cation Exchange Capacity - CEC
- Aeration
  - Ability to let air (atmospheric gasses) through.
- Acidity/Alkalinity
  - Presence absence of compounds releasing protons (H+)- Acids, or binding protons - Bases (OH-).
- Salts
  - Salts tend to retain water and even extract water from plants.

Soils as regulators of global climate changes

- The soil layer acts a membrane between the lithosphere, the hydrosphere, the biosphere and the atmosphere. Dissolved ions, sold particles, and gases pass back and forth through this soil membrane and it alters the nature of the underlying lithosphere creating nutrient rich environment for plants and animals. The alteration of rock and mineral matter at the soil zone by physical, chemical and biological processes is called weathering. Weathered rocks provide essential elements to plants and animals, which in turn transforms rocks in to soils, thus releasing the elements needed for life.

- Soils are the biggest reservoirs of carbon dioxide gas than any other reservoir. The soil system regulates the global climate by absorbing excess $CO2$ from the atmosphere over a long period of time.

Interaction between soil and other spheres of the earth system

- The soil system is an open system with fluxes(flow) of matter and energy from the lithosphere, biosphere, atmosphere, hydrosphere.
- The lithosphere contributes to the soil formation by adding mineral matter and sediments weathering processes transform primary minerals to secondary minerals such as clays and oxides and release ions from minerals to soil water making them accessible to plants and animals.
- The hydrosphere Is responsible for the transfer of solid2 and dissolved substances among soil horizons.
- The biosphere adds organic matter to the soil horizon.
- The atmosphere adds nitrogen and carbon dioxide to the soil.

Soil Erosion and degradation

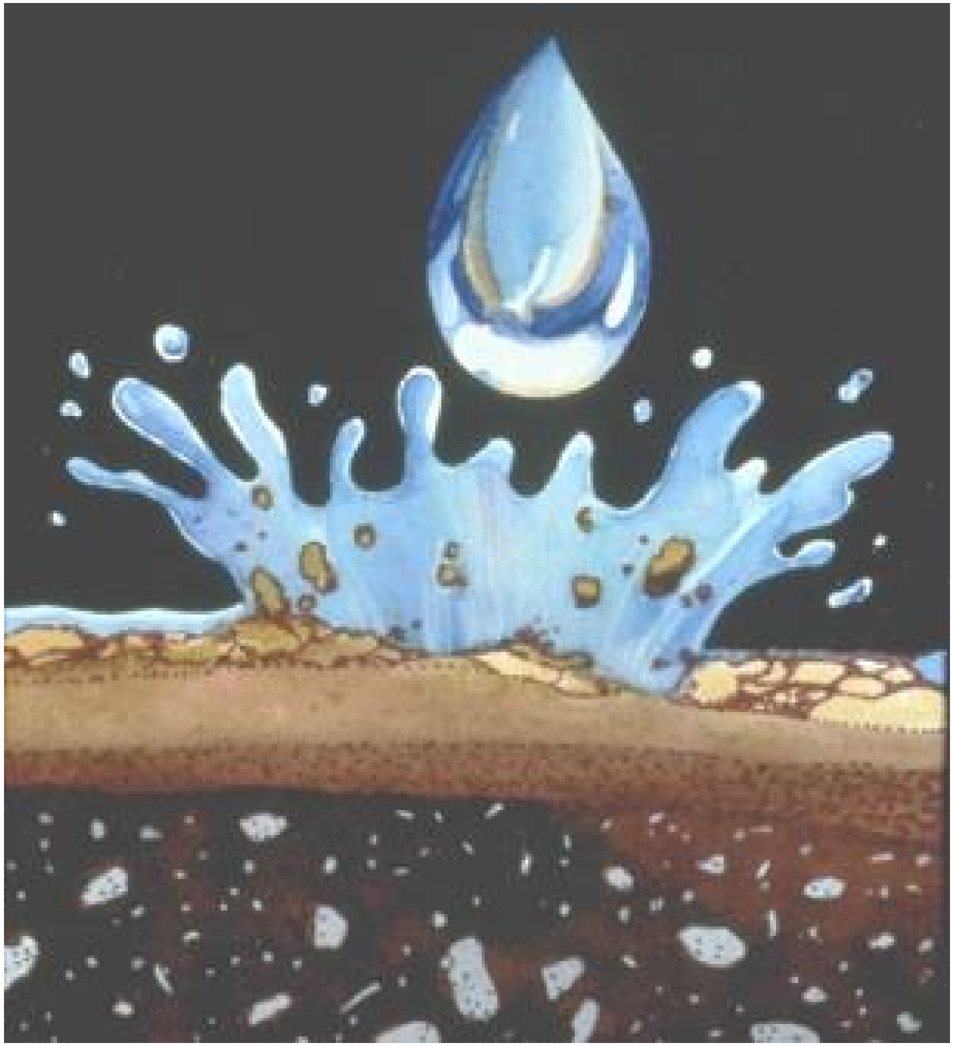
- Erosion is the process in which soil particles are detached and transported by the actions of wind or water.
- Natural vs. Accelerated Soil Erosion
- Natural geologic erosion has occurred at a relatively slow rate since the earth was formed.
- Accelerated erosion is the increased rate of erosion caused primarily by the removal of vegetation or the alteration of ground contours.

The Three Processes of Soil Erosion

- Detachment
- Transport
- Deposition

Detachment

- Raindrop impact energy is enough to dislodge surface sediments.
- Water erosion is the wearing away of soil particles.
- Raindrops detach the soil particles.
- As infiltration is reduced, water moving down slope takes the soil with it.



Transport

- Detached soil particles are transported by the energy of water flowing over ground and in channels.

- Additionally, soil particles in fluid systems (like watercourses and ditches) may also detach unprotected soil particles by physical action.

Rill Erosion

As flow concentrates, small channels begin to form in the soil surface.

Gully Erosion

- Gullies are formed when Runoff cuts rills deeper and wider or when flows from several rills come together and form a large channel.

Wind Erosion

Wind erosion is the detachment of soil particles by the wind and moving them to another location.

Several farming strategies to prevent soil degradation:

- Crop rotation
- Contour farming: Planting along contour lines of slopes helps reduce erosion on hillsides.
- Intercropping
- Terracing
- Shelterbelts

Chapter 10: Megacities and Solid Waste Management

- Megacities and various development challenges
- Solid waste management in cities
- Sanitary landfills design parameters
- Waste management challenges in cities/towns of Ethiopia

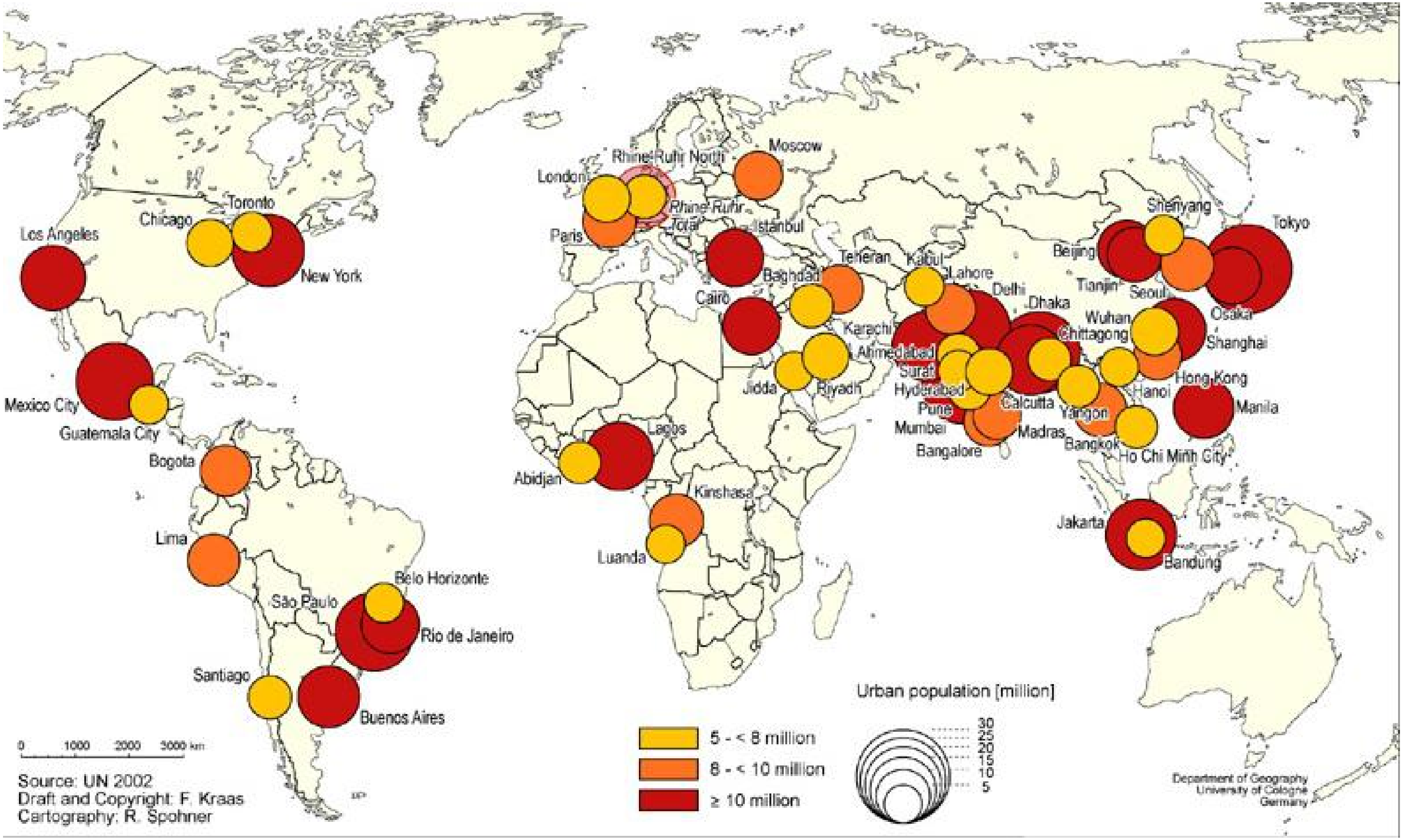
10.1. Definition

- A megacity is generally defined as a metropolitan area with a total population in excess of 10 million people – this is an updated definition. The definition changes with time.
- Due to rapid change in numbers
- In order to be sure: do some research to check how many megacities are currently in the world......and look at how it has changed....

In 2000, there were 18 megacities and by 2007 27 megacities of which ….are located in the developing world.....by 2009 ????

- Tokyo, (33,600,000)
- Seoul, South Korea (23,400,000)
- Mexico City (22,400,000)
- New York City, USA (21,961,994)
- Mumbai (Bombay), India (21,600,000)
- Delhi, India (21,500,000)
- São Paulo, Brazil (20,600,000)
- Los Angeles, USA (18,000,000)
- Shanghai, China (17,500,000)
- Osaka (16.7)
- Cairo (16.1)
- Kolkata (15.7)
- Manila (15.6)
- Jakarta (15.1)
- Karachi (15.1)
- Buenos Aires (13.6)
- Dhaka (12.6)
- Beijing (12.8)
- Lahore (12.7)
- London (12.5)
- Paris (12.0)
- Istanbul (11.8)
- Rio de Janeiro (11.5)
- Tehran (10.2)
- Lagos (10.1)
- Moscow (10.1)
- Bangkok (10.1)

World megacities



10.2. World Urban Population

- In 1800 only 3% of the world's population lived in cities.
- By the end of the 20th century 47% lived in cities.
- In 1950, there were 83 cities with populations exceeding one million;
- By 2007, this had risen to 468 agglomerations of more than one million.
- If the trend continues, the world's urban population will double every 38 years, say researchers.
- The UN forecasts that today's urban population of 3.2 billion will rise to nearly 5 billion by 2030, when three out of five people will live in cities

Urbanisation

- Urbanisation describes the increasing proportion of people living in urban areas (towns and cities) as opposed to rural areas (villages and country side).

- The main causes of Urbanisation
  – Rural-Urban migration
  – Population Increase

Reasons for growth of Megacities in the developing world….

- Economic Growth
- Natural Increase – High fertility rates
- Rural – urban migration

RURAL➔ URBAN MIGRATION DUE TO ***Push factors*** – these are:

- Increasing landlessness (no land ownership) due to loss of land from drought, crop failure, war, poverty, debt….
- War and civil disorder
- Intolerance
- Desertification
- Lack of Medical Facilities
- Rapid Population Growth
- Rural Poverty
- Lack of Educational opportunities
- Transfer of land from food production and self sufficiency to export crop production meaning less food for families therefore vulnerable to international commodity price fluctuations
- Lack of medical facilities

- RURAL URBAN MIGRATION ***Pull factors--*** (attraction of urban areas) due to:
  - Attracted to employment opportunities
  - Promise of higher living standards
  - Entertainment and Cultural events
  - Educational Opportunities
  - Medical facilities

Some of the problems of megacities include:

- Explosive population growth.
-
- Alarming increases in poverty
- Massive infrastructure problems with telecommunications services, transportation and congestion.
- For example, traffic congestion in Bangkok is so bad that the average commute now takes three hours
- Pressures on land and housing

- Environmental concerns, such as contaminated water, air pollution, and overdrawn aquifers. For instance, Mexico City's aquifer is being overdrawn and is sinking by about 1 meter per year

- Disease, high death rates, drug-resistant strains of infection, and lethal environmental conditions.

- For example, 12.6 percent of the deaths in Jakarta are related to air pollution causes
- Capital scarcity

- Dependence on federal or state governments for funding

10.3. Megacities and various development challenges

- Waste management
- Food, water and Energy insecurity
- Traffic management
- Freshwater scarcity
- High urban density, informal development
- Unsustainable land use and inefficient land administration systems
- Creation of slums and criminality
- Water, soil and air pollution
- Inefficient governance and bad governance
- Lack of green areas and buildings reflecting local culture

Solid waste management in cities

- increase in population and urbanization was also largely responsible for the increase in solid waste.
- Garbage generated in households can be recycled and reused to prevent creation of waste at source and reducing amount of waste thrown into the community dustbins.
- Four R's (Refuse, Reuse, Recycle, and Reduce) to be followed for waste management

- Four R’s (Refuse, Reuse, Recycle, and Reduce) to be followed for waste management
- 1. Refuse: Instead of buying new containers from the market, use the ones that are in the house. Refuse to buy new items though you may think they are prettier than the ones you already have.
- 2. Reuse: Do not throw away the soft drink cans or the bottles; cover them with homemade paper or paint on them and use them as pencil stands or small vases.
- 3. Recycle: Use shopping bags made of cloth or jute, which can be used over and over again [will this come under recycle or reduce?].Segregate your waste to make sure that it is collected and taken for recycling.
- 4. Reduce: Reduce the generation of unnecessary waste, e.g. carry your own shopping bag when you go to the market and put all your purchases directly into it.

Types of solid waste

- Solid waste can be classified into different types depending on their source:

Household waste is generally classified as municipal waste,

Industrial waste as hazardous waste, and

Biomedical waste or hospital waste as infectious waste.

Municipal solid waste

- Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes. With rising urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing. In 1947 cities

Garbage: the **four** broad **categories**

- **Organic** waste: kitchen waste, vegetables, flowers, leaves, fruits.
- **Toxic** waste: old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.
- **Recyclable**: paper, glass, metals, plastics.

Soiled: hospital waste such as cloth soiled with blood and other body fluids.

TREATMENT OF MUNICIPAL WASTES

Treatment and disposal of municipal waste

- As cities are growing in size with a rise in the population, the amount of waste generated is increasing becoming unmanageable. There are different methods for the disposal of this waste . open dumps, landfills, sanitary landfills, and incineration plants. One of the important methods of waste treatment is composting.

Open dumps

- Open dumps refer to uncovered areas that are used to dump solid waste of all kinds. The waste is untreated, uncovered, and not segregated. It is the breeding ground for flies, rats, and other insects that spread disease. The rainwater run-off from these dumps contaminates nearby land and water thereby spreading disease.

Landfills

- Landfills are generally located in urban areas where a large amount of waste is generated and has to be dumped in a common place. Unlike an open dump, it is a pit that is dug in the ground. The garbage is dumped and the pit is covered thus preventing the breeding of flies and rats. At the end of each day, a layer of soil is scattered on top of it and some mechanism, usually an earth-moving equipment is used to compress the garbage, which now forms a cell. Thus, every day, garbage is dumped and becomes a cell.

- After the landfill is full, the area is covered with a thick layer of mud and the site can thereafter be developed as a parking lot or a park.
- Landfills have many problems. All types of waste is dumped in landfills and when water seeps through them it gets contaminated and in turn pollutes the surrounding area. This contamination of groundwater and soil through landfills is known as leaching.

Sanitary landfills

- An alternative to landfills which will solve the problem of leaching to some extent, is a sanitary landfill which is more hygienic and built in a methodical manner. These are lined with materials that are impermeable such as plastics and clay, and are also built over impermeable soil. Constructing sanitary landfills is very costly and they are have their own problems. Some authorities claim that often the plastic liner develops cracks as it reacts with various chemical solvents present in the waste.
- The rate of decomposition in sanitary landfills is also extremely variable. This can be due to the fact that less oxygen is available as the garbage is compressed very tightly. It has also been observed that some biodegradable materials do not decompose in a landfill. Another major problem is the development of methane gas, which occurs when little oxygen is present, i.e. during anaerobic decomposition. In some countries, the methane being produced from sanitary landfills is tapped and sold as fuel.

Incineration plants

- This process of burning waste in large furnaces is known as incineration. In these plants the recyclable material is segregated and the rest of the material is burnt. At the end of the process all that is left behind is ash. During the process some of the ash floats out with the hot air. This is called fly ash. Both the fly ash and the ash that is left in the furnace after burning have high concentrations of dangerous toxins such as dioxins and heavy metals. Disposing of this ash is a problem. The ash that is buried at the landfills leaches the area and cause severe contamination.
- Burning garbage is not a clean process as it produces tones of toxic ash and pollutes the air and water. A large amount of the waste that is burnt here can be recovered and recycled. In fact, at present, incineration is kept as the last resort and is used mainly for treating the infectious waste.

Sanitary landfills design parameters

Engineering principles used to:

- **confine** waste to smallest practical area
- **reduce** waste to smallest practical volume
- **cover** waste with layer of compacted soil (or tarps)
- each day (finishing cover is ~50 cm or more of compacted clay-rich soil)

- Sanitary Landfills -- **Site Selection**
- **Best sites** have natural conditions to ensure reasonable safety in disposal of solid waste: **little** (or **acceptable**) **pollution of groundwater and surface water**.

  ➔ Must consider: **climate**, **hydrology**, **geology**, & **human conditions** (or **combinations of all**)

- Factors controlling the **feasibility of sanitary landfills**:
  - **Topographic** relief
  - **Location** of the **Groundwater table**
  - **Amount of precipitation**
  - **Type** of **soil** and **rock**
  - **Location of the disposal zone** in the **surface-water** and **groundwater flow system**
- NOTE: The ***best sites*** are in **arid** regions, **above water table**.

Arid Regions

- Relatively safe, regardless of whether burial material is permeable or impermeable, little or no leachate.

- Humid Regions
  - Some leachate always produced, need to establish acceptable level of leachate production
  - Need to consider local water use, local regulations, and ability of natural hydrologic system to disperse, dilute and degrade the leachate to make harmless
  - Most desirable to bury waste **above water table** in **clay and silt soils** having **low permeability**
  - Use **substrate** as a natural filtering system, even if water table is high (typical in humid climate)

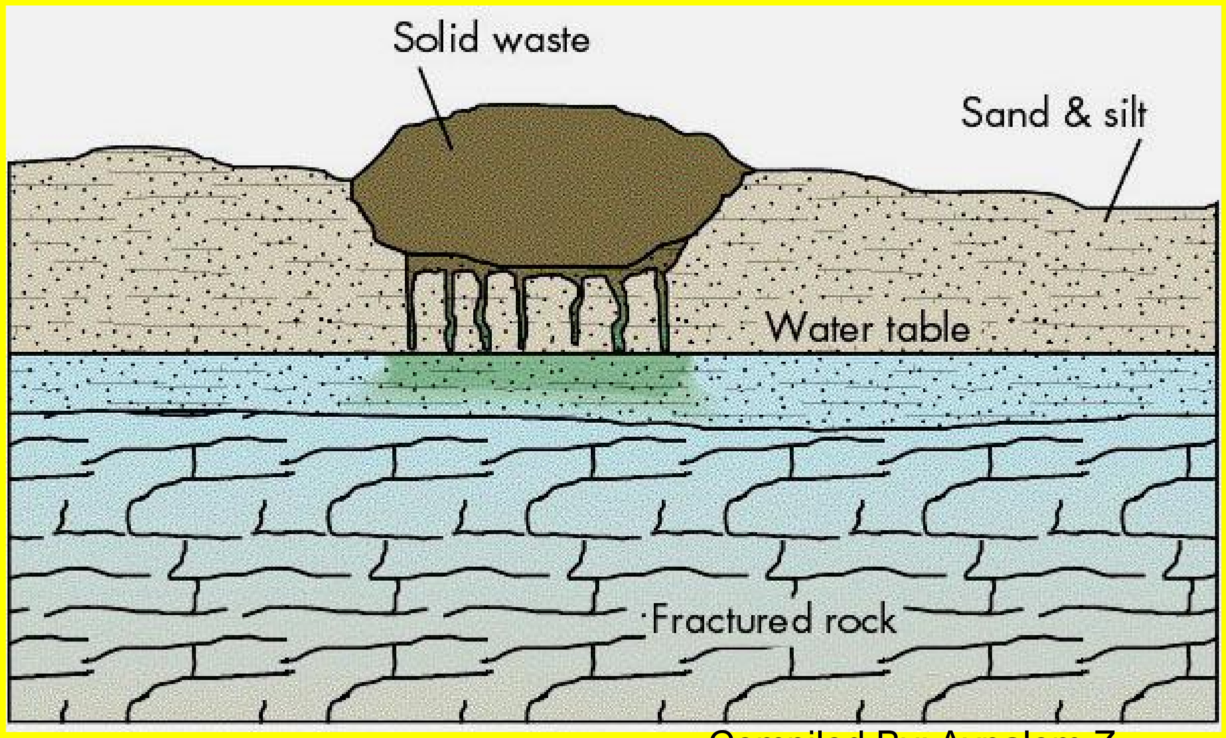
- NOTE: It is very important to consider the **geology** of the landfill site, **type of aquifer**, **types of soils**, etc.

- **Geologic mapping** is critical -- must be at least 10 meters between the base of the landfill and the top of the water table at its shallowest point - this includes anomalous shallow aquifers such as "perched aquifers". An event of high infiltration may cause the main aquifer to become hydraulically connected with the perched aquifer.
- Important factors to consider:
  - Natural filtration of the subsurface - contaminants may be removed from leachate before they reach the water table. Filtration can also occur by ion exchange or sorption.
  - Dispersion possibilities - migration will occur as a result of both physical and chemical gradients. It is also important to determine subsurface fractures.
  - Precipitation possibilities - heavy metals may precipitate out of leachate, or will they remain suspended

Example #1: Waste disposal site where the refuse is buried above the water table over a fractured rock aquifer.

➔ Low potential for serious pollution because leachate is partially degraded by natural filtering as it infiltrates through the unsaturated zone down to the water table.

➔ Dispersion of contaminant confined to fracture zones.



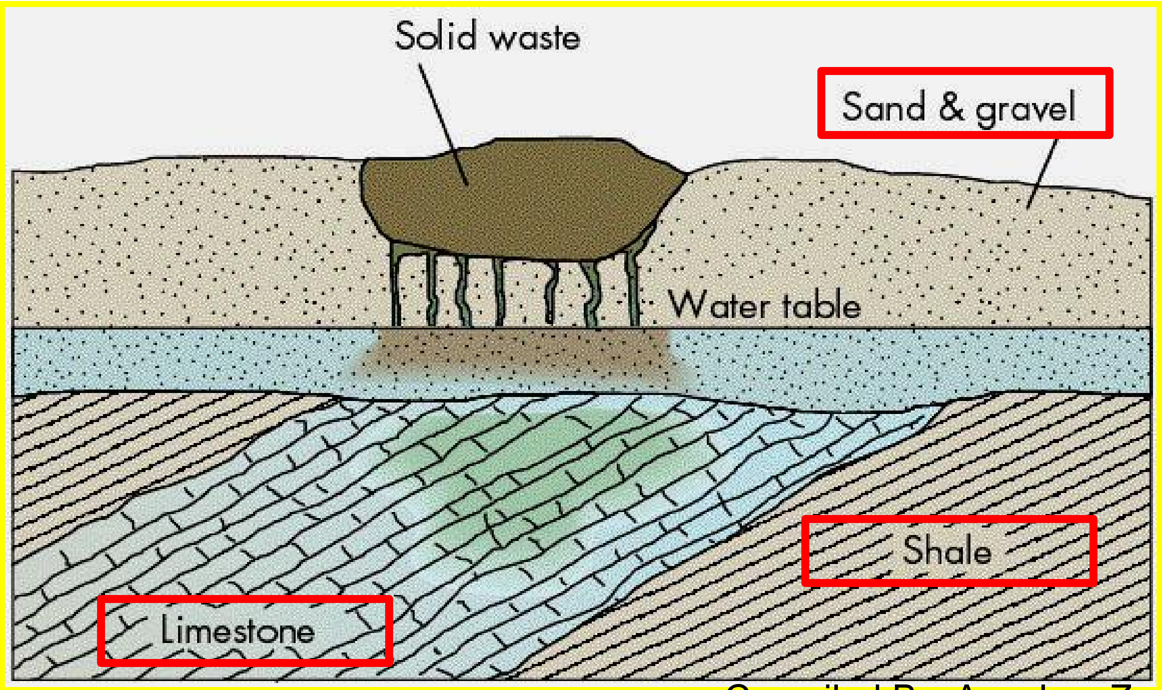
Problems if:

- Higher water table
- Thinner cover material
- Cover material has moderate to high hydraulic conductivity

Example #2: Solid-waste disposal site where waste is buried above the water table in permeable material with high hydraulic conductivity.

➔ Leachate can migrate down to fractured bedrock (limestone)

➔ High potential for groundwater pollution -- many open and connected fractures in the rock.



Leachate

Moves quickly through sand & gravel

Enters limestone, transported through open cavities and fractures

Has little degradation

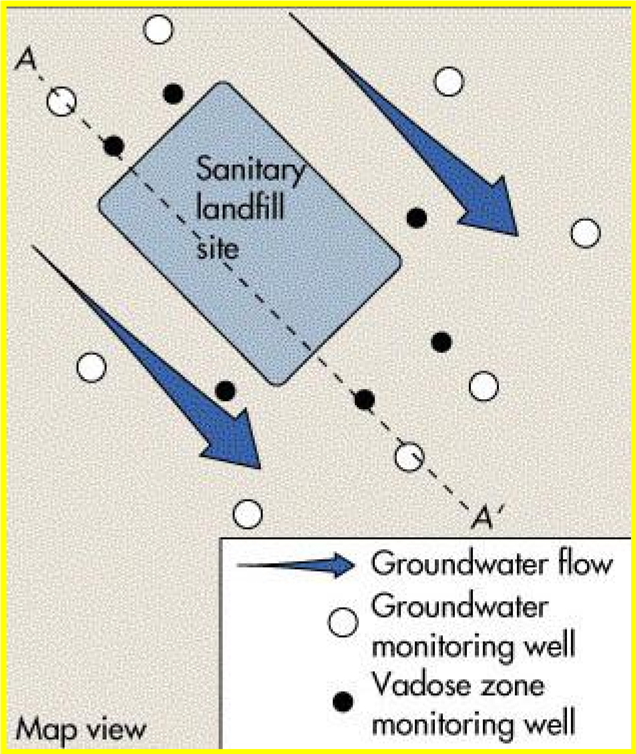
Sanitary Landfills -- Site Selection Guidelines

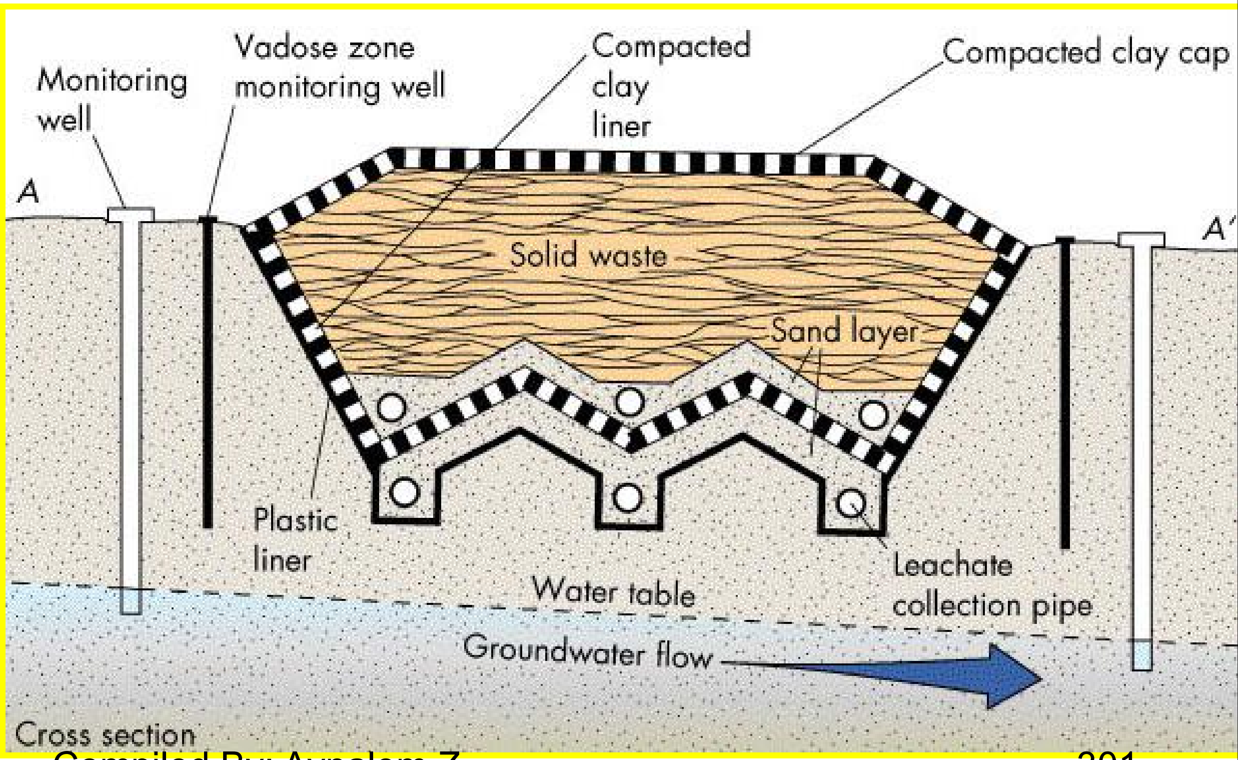
- **Poor or Unacceptable Landfill Sites**:
  - Limestone or highly fractured rock quarries, and sand and gravel pits (because they are good aquifer materials)
  - Swampy areas, unless properly drained
  - Floodplains, absolutely not acceptable
  - Areas near coast; trash or leachate will pollute beaches and coastal marine waters
  - Any area with high hydraulic conductivity and high WT

- **Acceptable Landfill Sites**:
  - In rough topography, areas near heads of gullies, where surface water is at a minimum
  - Clay pits, if kept dry
  - Flat areas, if a layer with low hydraulic conductivity (aquitard, clay and silt) is present above any aquifer

- Design of Sanitary Landfills -- complex, with **multiple barriers**: clay liner, leachate collection system, and a compacted clay cap
- **Idealized diagram** of a landfill with a double liner of clay and plastic, and a leachate collection system:

Map View **Cross Section**

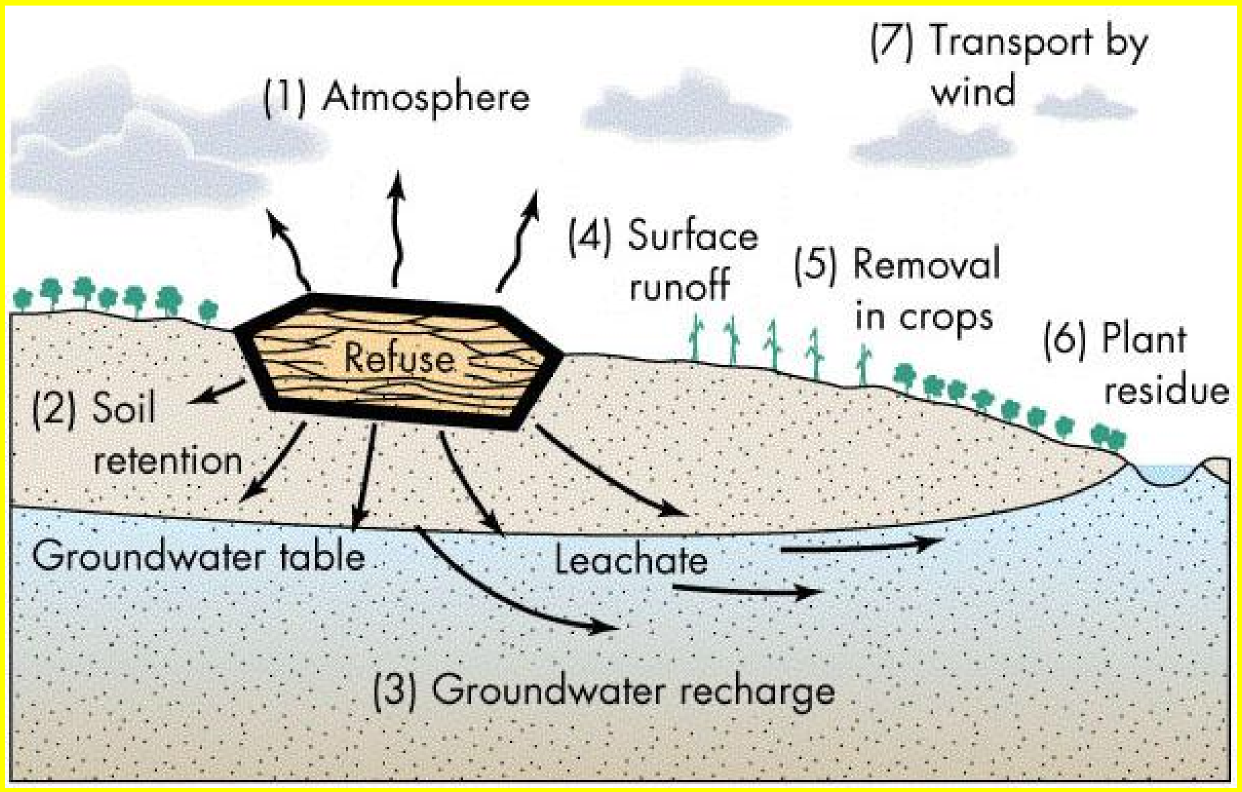




Monitoring Sanitary Landfills

Must begin monitoring the movement of groundwater before operating the site, then continued monitoring of movement of leachate and gases

Hazardous pollutants can enter the environment many ways:



1. Gases CH_4, NH_3, H_2S, N_2 go to the atmosphere
2. Heavy metals Pb, Cr, & Fe are retained in the soil
3. Soluble chlorides, nitrates, & sulfates go to groundwater

4-7. More pathways

USEFUL DEFINITIONS

- **LEACHATE** - Leachate is a combination of infiltrated precipitation and any liquids squeezed from the waste as it naturally compacts. Leachate will percolate to the base of land disposal sites due to the influence of gravity. Leachate can carry particulate matter, pollutants, biological contaminants and other constituents with it. Leachate will travel through the subsurface following the same flow direction as groundwater. Leachate is a potentially major source of pollution. As such all land based disposal facilities must incorporate a leachate collection and disposal system into their designs. Also liners and covers must be added so as to minimize infiltration into the waste site thereby minimizing leachate production or escape.

- **LINER** - Generally there are several layers of liners at the base of a land disposal site. Layers consist of compacted clay alternating with plastic. Leachate collection systems are placed just below the first and second (in case the first one is breached) liner layers. The purpose of the liner is to prevent leachate from escaping into the subsurface.

- **CAP/COVER** - Caps and covers are constructed (starting at the waste and working outward) of compacted, low permeability clay. This is followed by a flexible plastic liner (theoretically impermeable). Next comes a drainage layer designed to transport surface water away from the waste disposal site. Finally, this is followed by a layer of earth and then some type of vegetative cover.

RECYCLING AND REUSE

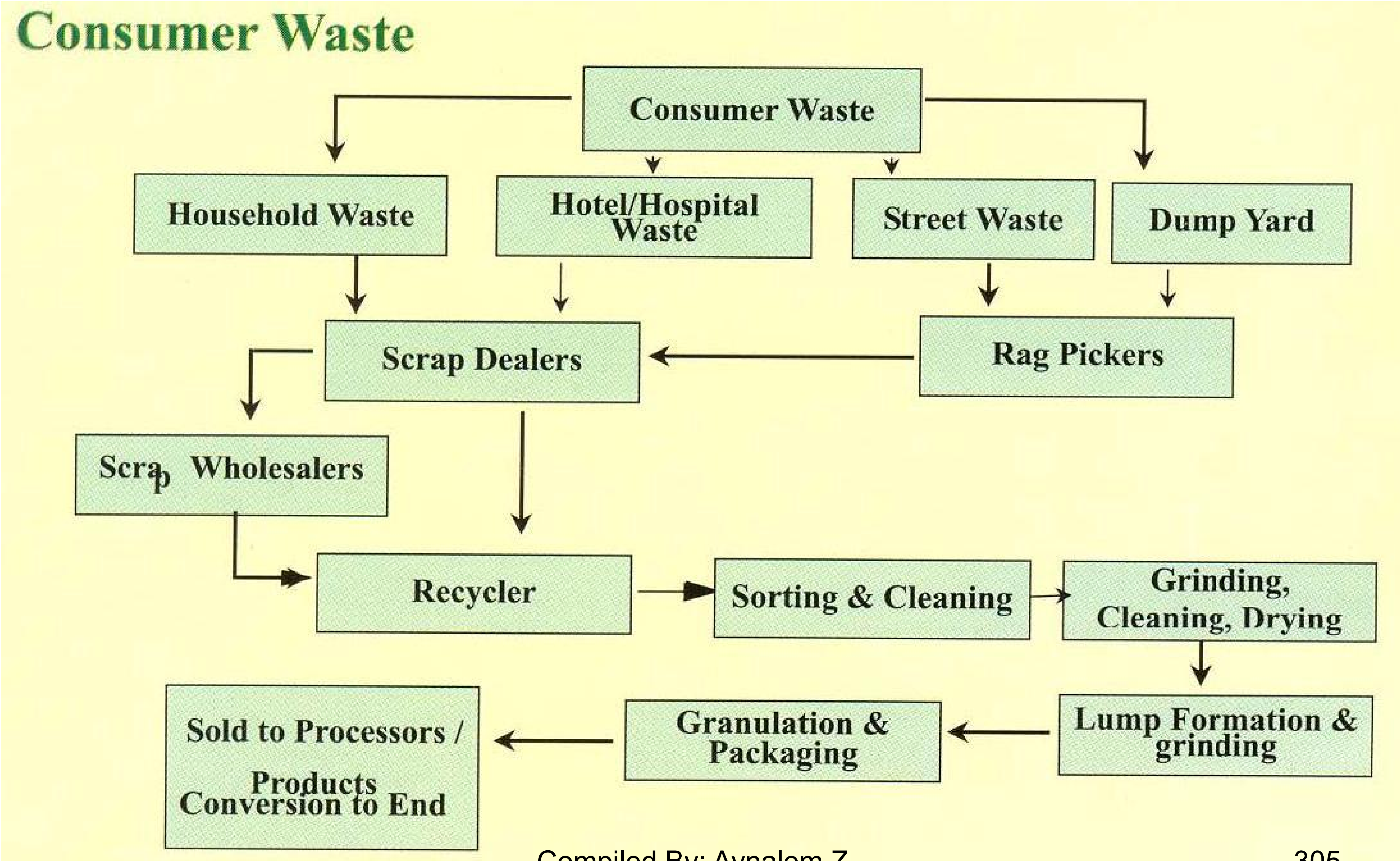
- Recycling involves the collection of used and discarded materials processing these materials and making them into new products. It reduces the amount of waste that is thrown into the community dustbins thereby making the environment cleaner and the air more fresh to breathe.
- The steps involved in the process prior to recycling include

a) Collection of waste from doorsteps, commercial places, etc.

b)Collection of waste from community dumps.

c) Collection/picking up of waste from final disposal sites and some of the items can be recycled and reused

flow chart recycling plastic waste



Waste recycling has some significant advantages.

It leads to less utilization of raw materials.

Reduces environmental impacts arising from waste treatment and disposal.

Makes the surroundings cleaner and healthier.

Saves on landfill space.

Saves money.

Reduces the amount of energy required to manufacture new products.

In fact recycling can prevent the creation of waste at the source.

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Sources of Waste Generated

- 76% households,
- 18% institutions ,commercial, factories, hotels,

6% is street sweeping.

PHYSICAL COMPOSITION

Organic 60%, Recyclables 15 % , Others 25%

- Vegetable 4.2 %,
- Paper 2.5%,
- rubber/plastics 2.9%,
- Wood 2.3%,
- Bone 1.1%,
- Textiles 2.4 %,
- Metals 0.9%,
- Glass 0.5%,
- combustible leaves 15.1%,
- Non-combustible stone 2.5%,
- All fine 65%

DISPOSAL OF SOLID WASTE in Addis Ababa

- There is currently one open dumpsite where all collected waste is disposed off.
- It has been established 47 years ago.
- The site is known as "Rappi" or "Koshe" which is South West part of the city
- Located 13 km away from the city center.
- It has a surface area of 25 hectares.
- The present method of disposal is crude open dumping:
- hauling the wastes by truck, spreading and leveling by bulldozer and compacting by compactor or bulldozer.

Challenges: DISPOSAL OF SOLID WASTE

major problems associated with the disposal site :

- The site is getting full
- Surrounded by housing areas and institutions
- Nuisance and health hazard for people living nearby
- waste pickers per day, interfering with the work
- No daily cover with soil
- No leachate containment or treatment
- No rainwater drain-off
- No odor or vector control
- No fence

MAJOR IDENTIFIED PROBLEMS & GAPS

CHALLENGES

- Low service coverage
- Collection,
- Street Cleaning,
- Reuse/Recycling
- High Operational cost
- Poor Quality of Services
- Very low customer Satisfaction
- Lack of Environmentally Sound, effective & efficient System

The Four R's principle

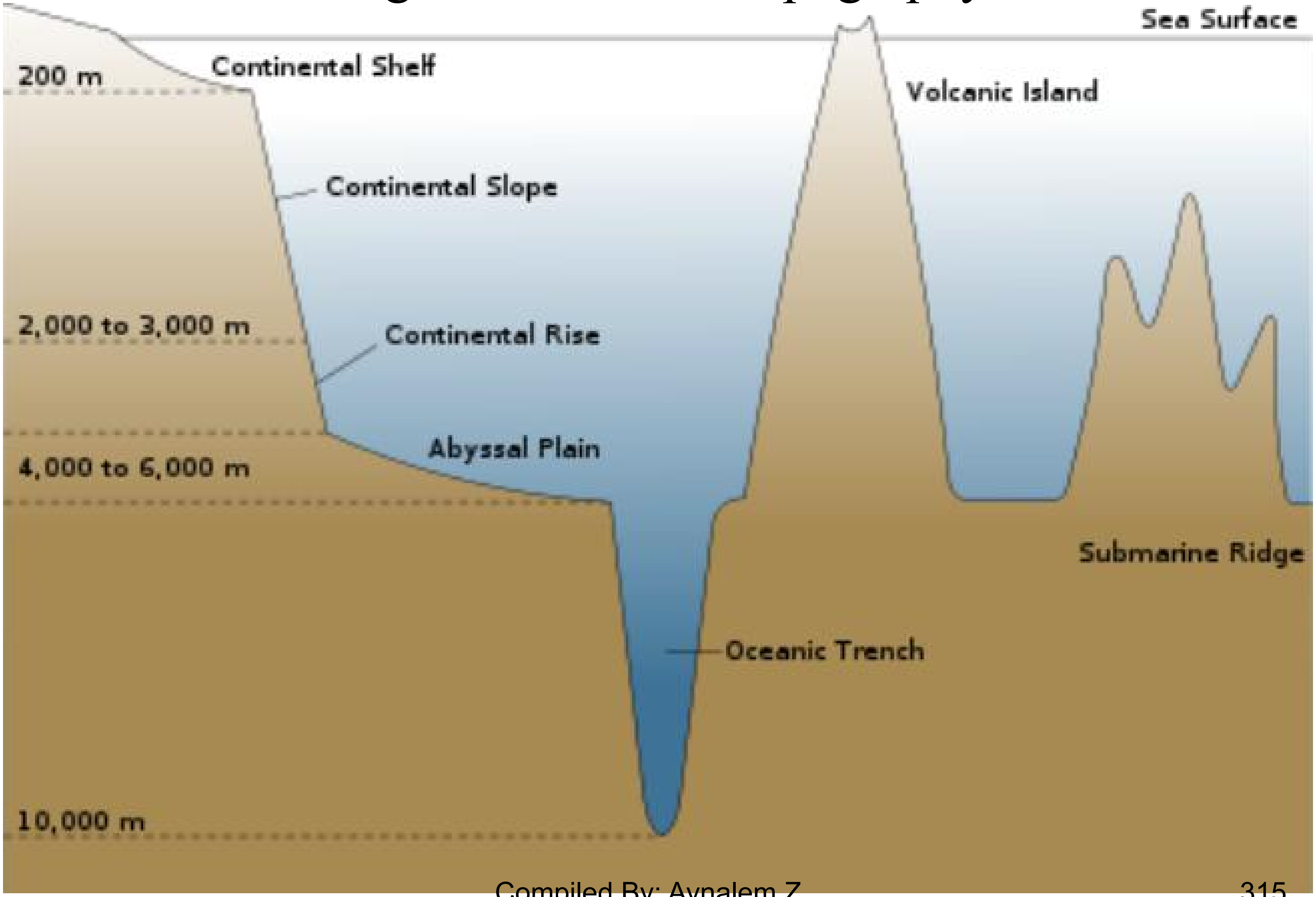
Chapter 11: Oceans and the Environment

- Ocean resources, ownership of oceans, international laws on oceans
- Oceans as sinks of global CO_2
- Interaction between ocean waters and adjacent lands

The Oceans

- 71% of our planate is covered by water
- There are **five major interconnected ocean basins**, the Atlantic, the pacific, the Indian, the Arctic and the Antarctic ocean basins.
- Seas: smaller bodies of water enclosed by land masses, yet still connected with oceans. Like-the Caribbean sea, the red sea, the North sea, the Mediterranean sea.
- Bathymetry: the science of the study of the sea floor topography by measuring the depth of the water.
- Common under sea topographic features are: Continental shelf, continental slope, continental rise, abyssal plane, mid oceanic ridge, and deep sea trench,

Figure: Under sea topography



11.1. Ocean resources, ownership of oceans, international laws on oceans

Ocean resources

- The oceans are a great global commons, belonging to no single nation.
- There are enormous resources in the sea and with help of geophysical and satellite technology recently, huge resources are extracted, e.g. 80 million tons of fish harvested each year, oil is being drilled and ores are mined hundreds of meters deep under ocean water.
- With population growth and as the demand for resources increases, so does international conflict; who owns the oceans and seas? Who has the right to its fish, oils and minerals?

ownership of oceans

- In the 1970's and 1890's, the United Nations convened several conferences on the "Law of the Sea" in order to divide the ocean in to areas of national and international jurisdiction. Ultimately, the area in 200 nautical miles (370 Km) of the countries shore was defined as the countries Exclusive Economic Zone (EEZ).
- In their EEZ, countries have exclusive right to the oceans natural resources, but the rest of the sea is open to all.

Oceans as sinks of global CO_2

- What are the major constituents of the ocean water?
- Salt (dissolved inorganic substance), organic nutrients.
- CO_2 and O are the gases that are mainly exchanged between the ocean water and the atmosphere. The amount of CO_2 added in to the atmosphere and the oceans has Recently increased due to human action.
- Carbon dioxide is the means by which carbon is cycled through earths systems.
- The cycling of carbon affects the rate of growth of plants and weathering of rocks as well as the temperature of the atmosphere.

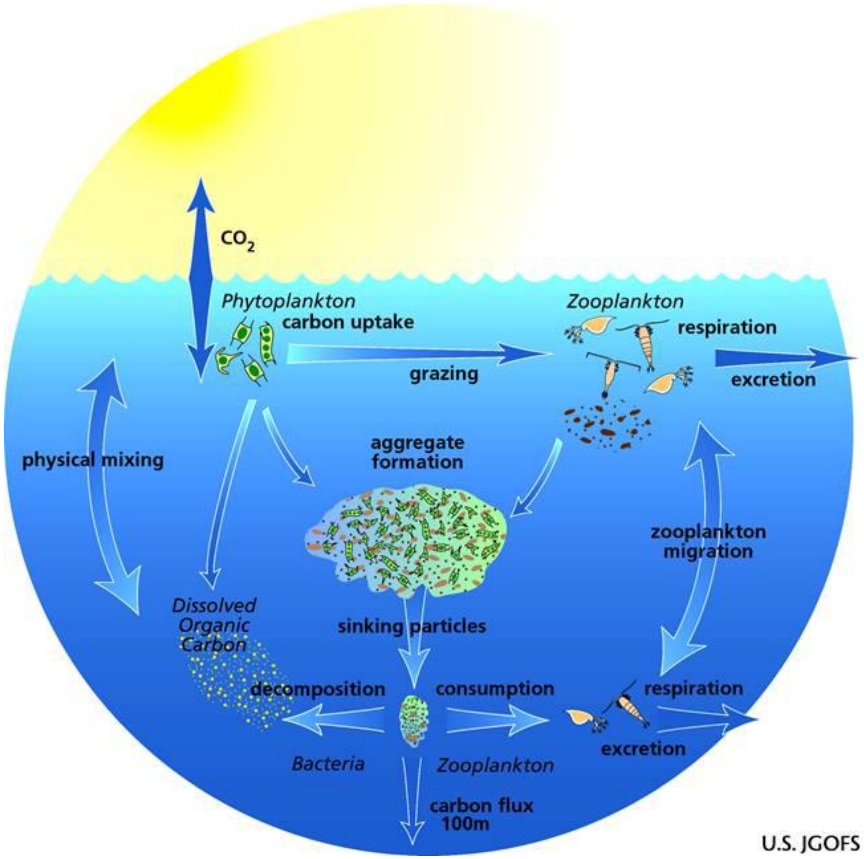
- The carbon cycle is the continuous cycling of carbon among seven major reservoirs. In order of decreasing stocks (amounts) these are the lithosphere (sediments and sedimentary rocks), the deep ocean, fossil fuels, soil, atmosphere, the surface ocean, and plants.

- Carbon dioxide is removed from the atmosphere

1. **chemically** through weathering of rocks and
2. **biochemically** through photosynthesis by plants.

What is the role of the ocean as a carbon sink?

45% of annual carbon flux is processed by phytoplankton



- Plankton grow, mature and die—taking carbon with them to the deep ocean
- They have a larger effect on climate than any single other process or group of organisms.
- Of the ~750 billion tons of CO2 that turn over annually, plankton process 45%
- 99% of marine life relies on plankton—they form the base of the marine food chain.

Plate tectonics, mountain building, subduction and volcanic eruption processes play important role in controling the amount of CO_2 released in to the atmosphere.

Chemical weathering

Atmospheric CO_2 + rainwater= weak carbonic acid (H_2CO_3)

Rocks weather chemically

Carbonate minerals dissociate in to ions Ca^{2+} and HCO_3^-

Ions run off in to rivers

Taken up by marine plants and animals, organisms change Ca^{2+} and HCO_3^{-} in to hard skeletons, Shells of calcium carbonate

Marine organisms die and precipitate to form carbonate rich organic sediments

Carbonate sediments subducted in to the mantle, melt, and release CO_2 back to the atmosphere

Remaining carbonate sediments compacted, form carbonate rocks, uplifted by tectonic/orogenic processes, chemically weathered.

Human activity affects the amount of CO2 cycled between various reservoir. The ocean is the most important reservoir of CO2 because it absorbs the surplus CO2 released from fossil fuel burning and deforestation.

In Marine photosynthesis

Marine organisms take up CO_2,	Marine photosynthesis is the major source of organic matter in petroleum genesis

↓

On land photosynthesis

Land plants die, their body added in to the soil-soil organic matter	Or dead plants body buried to form coals

↓

Human beings

Burning of fossil fuels release CO_2 in to the atmosphere	Burning of forests

Interaction between ocean waters and adjacent lands

- The oceans and the land are connected through exchange of matter and energy
- The continent supplies the oceans through supply of sediments through continental weathering and erosion from continental highlands
- The continent supplies the oceans with elements like Ca^{2+} , Mg^{2+}, Na^{+} and others…released from the continental rock masses through the process of weathering
- Surface water bodies like streams and ground water flows add water in to the oceans
- The oceans and the continents are connected through global hydrologic cycle
- The modification of the ocean floors by the continental drift, seafloor spreading and subduction processes continuously modifies the shape of the oceanic basins and the flow of oceanic currents.

- The convectional currents along the spreading ridges supply the ocean floor with heat and gasses like CO_2 and SO_2 are greatly added into the oceanic floor during submarine volcanic eruptions
- Seawater is added in to the coastal continental landmasses through subsurface flows (seawater intrusion)
- Storm surges and tidal currents modify the shape of coastal lines and create various coastal landforms
- The ocean water absorbs large amount of the solar electromagnetic radiation and hence, regulates the energy balance between the sun and the other spheres of the planate
- All the above points show the significant interaction between the oceans and the continents/land

Chapter 12: Environmental Geology and Land use Planning

- Risk/Hazard analysis and management
- Group discussion on linkage between geology and various land uses

12.1. **Introduction**: Land Use Planning **Basics**

- **Environmental Geology = Applied Science**
- Evaluate **Natural Hazards**
  - » -floods, landslides, volcanic activity
  - » -earthquakes, weather events
- **Environmental Impact Analysis**
  - » -site selection, land-use planning
- Assess **Earth Materials**
  - » -minerals, rocks, soil, WATER
  - » -analysis of chemical properties
  - » -analysis of physical properties
- Environment = "**everything**" (surroundings, **habitats**, etc.)
  - Physical Conditions: air, water, gases, landforms
  - Social and Cultural: ethics, economics, aesthetics,
- politics, religion

What is Risk?

- Risk is the **probability or likelihood** of an ***adverse effect*** **due to some *hazardous situation***
- **Safety** is the complement of risk, or the ***probability that an adverse effect will not occur***

- **Risk = f (Hazard, Exposure)**

- **Magnitude** or severity of risk are a function of the type of harm i.e. **Hazard** and the extent or likelihood of **Exposure**

Risk Management

- Risk management is the process of **identifying**, **assessing**, and **controlling** **risks** arising from operational factors and making decisions that balance risk costs with mission benefits.

5 Steps of Risk Management

Step 1. Identify hazards.

Step 2. Assess hazards to determine risks.

Step 3. Develop controls and make risk decisions.

Step 4. Implement controls.

Step 5. Supervise and evaluate.

Land use Planning

- What Is Landuse Planning?
  - Landuse Planning - a process for deciding the best present and future use of each parcel of land in an area
- What Is a Landuse Plan?
  - A policy decisionA formalized concept of what a company, city, or neighborhood intends for itself and thus will strive to become
  - An articulation of planning goals - the driving force behind landuse planning

- linkage between geology and various land uses

- Land Use Planning – Why?
- Safety?
- Is it the best use of a tract/area of land?
- Will the intended use be a misuse of the land?
- Are the resources required (water – for example) for the intended use available?
- Is there a potential for pollution from this intended use of a tract of land?

Considerations in Planning

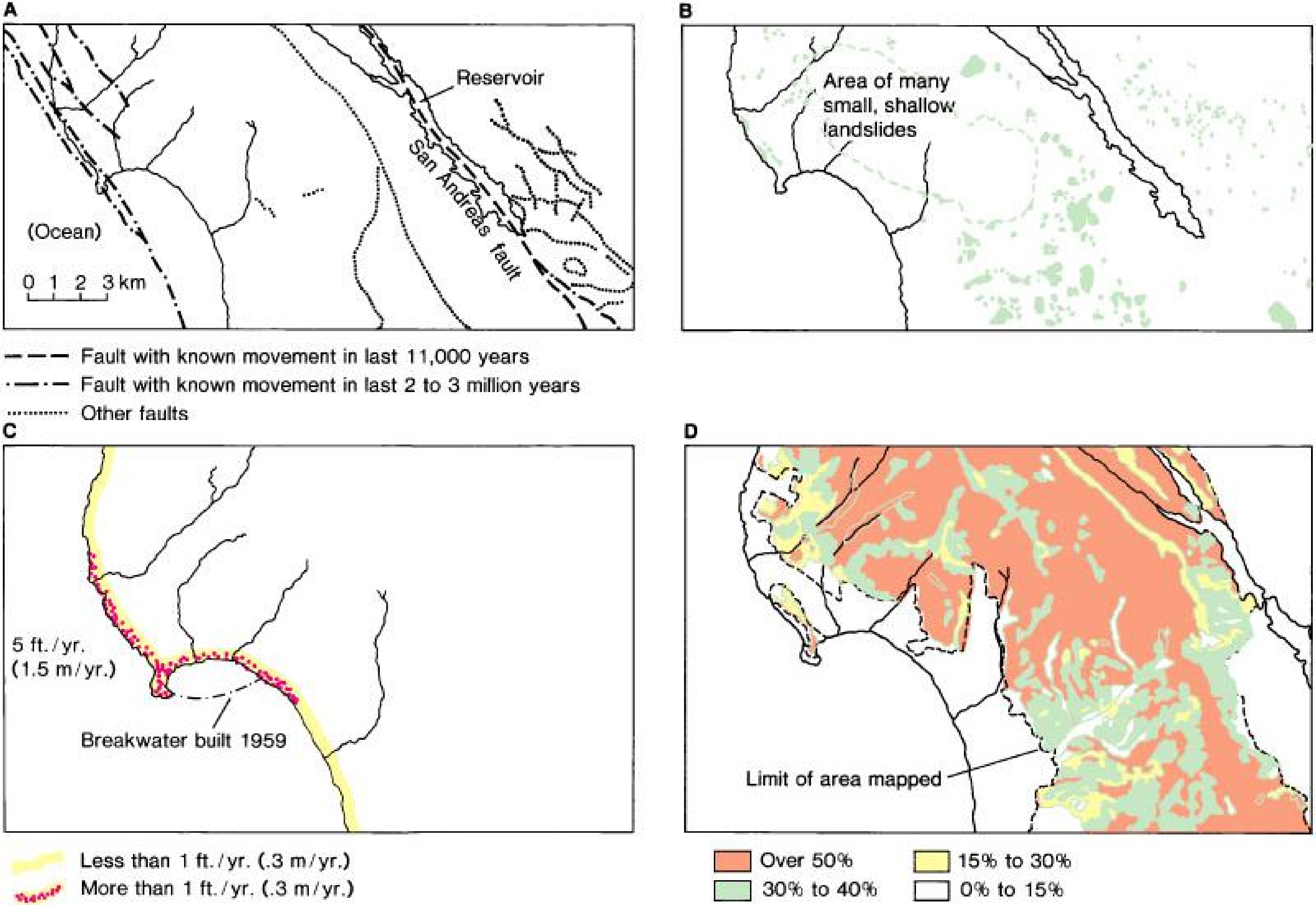
- What is the optimum use of a tract of land?
- We must consider:
  - Biological factors
  - Ecological factors
  - Geological factors
  - Economic factors
  - Political factors
  - Aesthetic factors

Land-Use Options

- Multiple Use – using the same land for two or more purposes
  - Parks or green areas used for recreation and to catch fresh water during a storm to allow it to infiltrate into the ground water
- Sequential use – utilize the land for two or more different purposes, one after another
  - Mines are used to provide the commodities found in the subsurface, then they are re-used for sanitary waste dumps, storage, or in-filled for parks

Maps as a Planning Tool

- Land use planning requires abundant information, maps often provide much of the information:
  - Topography, bedrock geology, surface materials and geology, soils, depth to ground water, vegetation, population information, location of fault zones and flood plains, and more
  - Maps can assist planners in long term planning, establishing restrictive zoning for earthquake or flood hazards, avoidance of other hazards as well



Map representation of geologic considerations

Maps as a Planning Tool

- Computers have aided planners
  - Information required by planners is voluminous
  - Computers have played an increasing role for planners to manipulate large volumes of quantitative information
  - Geographic Information Systems (GIS) allow planners to manipulate the data to see and use what data is useful to a planning task while minimize, or obscuring, unimportant data
  - GIS can allow a planner to see distinct "layers" of information that are important to the decision making process

Important advantages of Land use planning

- Decisions:
  - balanced and informed;
  - a planning system that accommodates change and lack of data;
  - considers present and future land-uses
  - considers present and future interests and needs;
- Meet the needs and interests of:
  - Aboriginal communities;
  - Region;
  - Ontario;
  - Canada;
  - Global community.

One Desired Outcome State of Change

- Decisions:
  - balanced and informed;
  - a planning system that accommodates change and lack of data;
  - considers present and future land-uses to accommodate present and future interests and needs;
- Meet the needs and interests of:

Chapter content

Environmental Geology

Chapter-13: *: Environmental Impact Assessment (EIA)*

- **Introduction: *definition and objective***
- **Major Issues In EIA process**
- **The EIA Procedure**
- **Application of EIA in different sectors**
- **Environmental Auditing**

Chapter-13*: Environmental Impact Assessment (EIA)*

13.1. Introduction: ***definition and objective***

-EIA as a process of identifying the likely consequences of particular activity on the biogeophysical environment and conveying the result to those responsible.

- EIA is not ***aimed*** to force decision makers to adopt the least environmentally damaging alternative

- but at seeking the ***balance*** between the often competing demands of development and environmental protection

- social and economic factors may be far more pressing than caring for the environment

-In the past: decision makers concern was economic benefits to exceed the cost (cost benefit analysis as basis for project appraisal) ‘impact’ and ‘effect’ are frequently used exchangeably, though

effect can refer to natural and man-induced changes in the biogeophysical environment while

impact can refer to the consequences of these changes over time and space

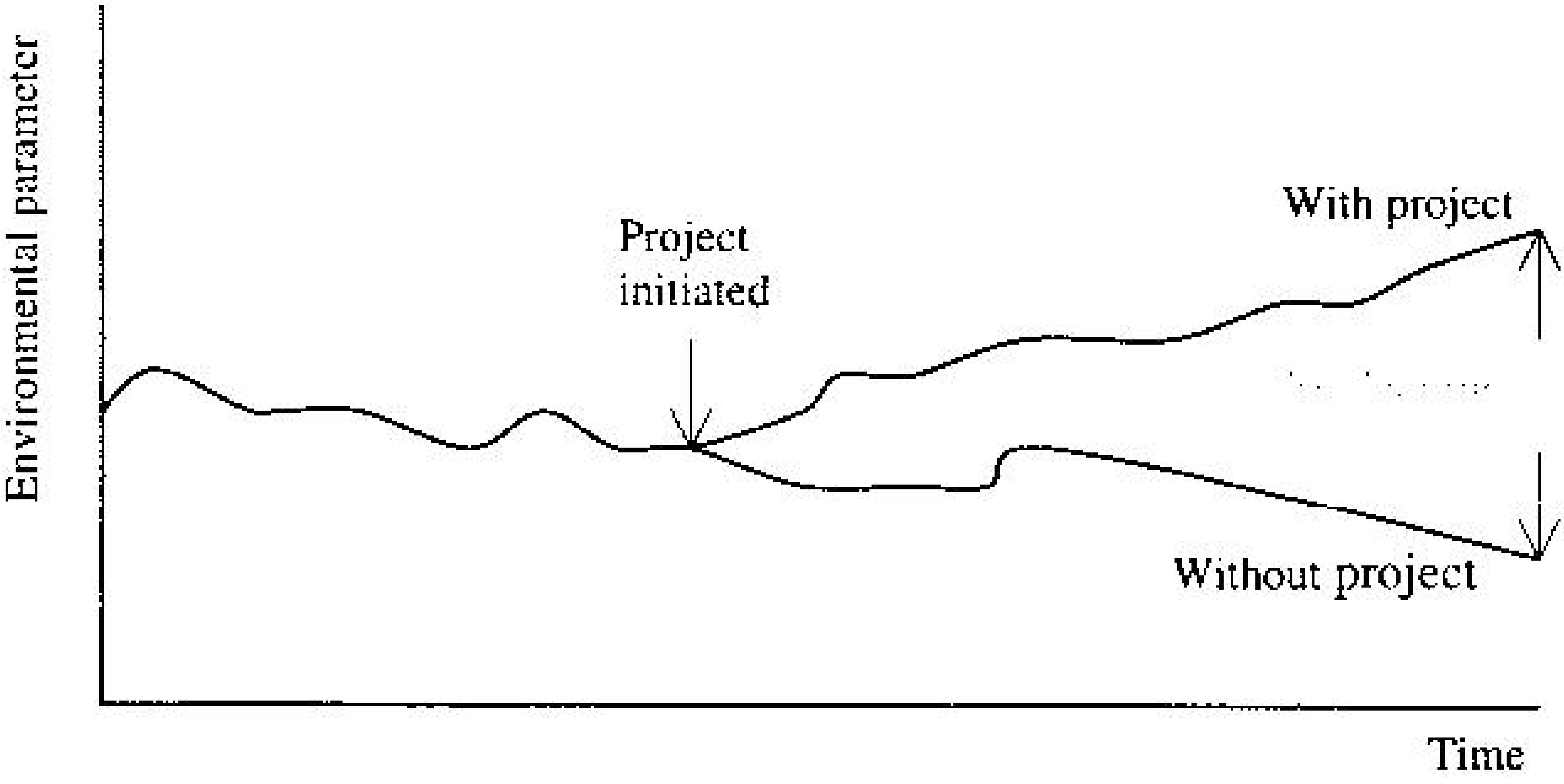
Impact defined as having spatial and temporal dimensions:

- *as the change in an environmental parameter, over a specified period and within a defined area, resulting from particular activity compared with the situation which could have prevailed had the activity not been initiated*.

There is a need to distinguish between impacts which are:

- Positive or negative
- Reversible or irreversible
- Temporary or permanent
- Short term or long term
- Direct or indirect

There is failure to establish time frame indicating when impacts are likely to be manifested because spatial aspects are usually considered more adequately than temporal ones.



13.2. Major Issues In EIA process

-Some deal with technical matters such as impact identification and prediction

-Most deal with information management with in the process

► **Identification of projects requiring EIA**

-careful, thorough and detailed analysis of the likely implications of a devt.

-Indicates need for some threshold of 'significance' being exceeded as to trigger full EIA process, *screening*

- many countries have developed lists of projects which should be subjected to EIA
  - *main concern – project location*
    - *project type*
    - *project size*
    - *consequence of possible impacts*

➢ **Identification of impacts to be assessed**

- many of the impacts of a proposed development may be of no significance to decisions which in practice, turn upon only a small subset of crucial issues

➢ **Assessment of Impacts**

- directly linked to *project size* and *project area* sensitivity

Check list method

- Gives a frame work for EIA not to forget any important point
- Sufficient for small scale projects but cannot consider all particular cases, not exhaustive
- Example of checklist for impact category of land development projects

1. *Local economy*: public fiscal balance, employment, wealth
2. *Natural environment:* air quality, water quality, noise, wildlife and vegetation, natural disasters
3. *Aesthetics and cultural values:* attractiveness, natural scene, landmarks
4. *Public and private services*: drinking water, hospital care, crime control, feeling of security, fire protection, recreation, education, transportation…
5. *Other social impacts*: people's displacement, special hazards, friendliness, privacy..

Matrix method

- Best known method for predicting the impact of a project on the environment.

- Two dimensional matrix cross-referencing
  - the related activities supposed to have impact on man and environment
  - the existing environmental and social conditions possible to be affected

- Applying *magnitude* and *importance* weighing numbers for the interactions between the two sides of the matrix
  - magnitude: degree of interaction
  - importance: degree of concern for the interaction

Example of matrix method for impact assessment

magnitude / Importance			Relevant activities									
			Rawmaterial production	Constuction buildings	Water supply	Energy supply	Cement production	Gaseouse emissions	Liquid effluents	Cooling water discharges	Running noisy machines	Heating of furnaces
Environmental conditions	Physical conditions	soil	4/8	5/8	8/8	4/8	6/8	8/4	8/7	8/3	8/8	1/8
		water	5/2	8/8	7/8	8/4	8/4	8/8	8/8	5/8	8/8	8/3
		air	4/5	8/8	8/5	8/7	8/8	5/8	8/5	8/5	8/5	5/8
	Biological conditions	fauna	6/6	9/5	8/4	8/8	4/8	8/5	8/8	8/6	8/8	8/4
		flora	8/8	8/5	8/8	9/8	8/6	8/5	8/8	4/8	4/6	8/8
		ecosystem	8/5	8/5	6/8	8/7	8/8	8/8	8/3	8/5	8/8	7/5
	Social conditions	population	4/8	8/6	4/8	8/8	8/8	9/8	4/8	8/4	7/8	8/8
		economy	8/6	8/5	4/8	8/7	8/8	2/8	8/2	8/3	8/8	2/8
		land use	8/3	8/7	8/5	8/8	8/8	7/8	8/5	8/8	8/7	4/8
	Aesthetic conditions	natural scenes	8/4	6/8	9/5	5/8	5/8	4/8	8/8	2/8	8/8	8/6
		historical sites	8/8	8/5	3/8	8/6	8/6	7/8	7/8	8/8	4/5	8/5

Completion of appraisal

- Final decision w.r.t. project authorization, but if assessment halt at this point, no way of knowing whether predicted impacts actually occur.

- Post implementation, *monitoring*, feedback can be used to
  - refine the proposal by adding remedial measures and/or relaxing constraints which are unnecessarily restrictive
  - modify the decision which in extreme case, can be rescinding authorization if predictions severely exceeded by adverse impacts
  - assess the accuracy of EIA, *auditing*

13.3. The EIA Procedure

- The structure of an EIA process is dictated primarily by the need to accommodate each of the key issues

- EIA is a multi-stage procedure prior to any development that may have negative impact on the environment

- This procedure includes a set of measures envisaging
  - review of the *state* of the environment at the given territory
  - review of the environmental *impact* of the development
  - preparation of proposals for *reduction or prevention* of negative impacts
  - establishment of monitoring mechanisms for *monitoring* the remaining impacts

The EIA procedure comprises the following phases

1. ***Project proposal***

- written project proposal by proponent to EIA agencies
- should include all relevant information available including land use map

2**. *Screening***

- to see whether a project requires environmental clearance as per the legal notifications

3. *Scoping*

- scoping is a process of detailing the terms of reference of EIA, manageable number of important questions; *planning stage*
- Quantifiable impacts assessed based on: *magnitude, dominance, frequency and duration*
-Non quantifiable impacts such as aesthetic or recreational value assessed based on *socio-economic criteria*

4. ***Baseline data collection***

- Existing environmental status of the identified area
- May be collection of available data or acquiring new data
- Account for most part of the total EIA cost

5. Impact prediction and assessment of alternatives

- Depicting the environmental consequences of the significant aspects of the project and its alternatives
- For all projects alternatives should be identified with regard to project location and process technology
- Alternatives should be ranked and compared over given criteria
- Mitigation should be drawn up for the selected option

6. EIA report

- Outcome of an EIA is usually document
- Should provide clear information to decision maker on the different environmental scenarios:
    - with out the project
    - with the project
    - with project alternatives

7. Public hearing

- Public must be informed and consulted on a proposed development after EIA report's completion

8. Decision making

- Involve consultation between the project proponent (assisted by a consultant) and EIA authorities (assisted by expert group)

9. Impact monitoring

- Aimed at detecting an impact whenever occurred and estimating its magnitude
- Considers that any change is a consequence of the project and not the function of some other cause
- the change can be due to natural variations in the parameter monitored or due to other developments in the vicinity
- Benefits:

  - identify harmful trends before it is too late to prevent them, early warnings device

  - improve knowledge about the impact of various projects on specific environments

EIA in Ethiopia

- Past development practices fell short of *anticipating, eliminating or mitigating* potential environmental problems early in the planning process
- For sustainable development, it’s essential to integrate environmental concerns into development activities
- Later EIA considered as one of environmental management tool

EIA Stages in Ethiopia each to be reported separately

1. *Pre-screening consultation*: proponent & govt agencies agree on how to proceed with EIA
2. *Screening*: determine whether EIA is required or not and the level of EIA to be conducted

3. *Scoping*: identifies boundaries of EIA, important issues of concerns, significant effects and factors to be considered, potentially affected groups, reasonable alternatives, appropriate methodologies, terms of reference
4. *EI study (EIS):* involves impact prediction and analysis, alternative comparison, Envt<u>al</u> management plan (mitigation, monitoring activities)
5. *Reviewing*: determines whether the EIA report is adequate in examining the environmental effects, and in having sufficient relevance & quality for decision making
6. *Decision making*: whether or not the proposal is to proceed and under what conditions

   - should be consultative, participatory and influence others to behave responsibly & sustainably

Roles and responsibilities of involving **parties**

1. **Proponent:** responsible for complying with the requirements of the EIA process

2. **Consultant:** act on behalf of proponent and is institution with required qualified professional team

3. **Interested and affected parties:** may include local communities, work force, customers & consumers, environmentalist and general public

   - their input to be considered during the scoping phase, in assessing and mitigating impacts and in review of EIS

4. **Competent agency**: federal and regional EPA

   - make sure the proponent/consultant complies with EIA requirements

13.4. Application of EIA in different sectors

- EIA can be applied in specific development sectors to ensure that projects which are likely to have a significant effect on the environment are assessed in advance so that people are aware of what those effects are likely to be.

- EIA identifies the possible impacts as well as mitigation measures that should be considered for a particular project in an economic sector

- EIA is required in many sectors like mining, food and chemical industry, dams and reservoir, infrastructure & waste dump

- Here mining & dams are considered as examples

- **Mining**

- Has permanent environmental impact since non-renewable natural resource is being exhausted

- Environmental impact can occur **during all phases** of mining project: *exploration* (deforestation, pitting, trenching, vehicles), *waste rock & overburden* disposal, *ore processing* and *plant operation* (by products, machineries), *tailing* (processing waste), infrastructure (access, water and energy) and construction of camps and towns

- The purpose of EIA here is to identify, predict and communicate potential EI's in all its phases

  - from exploration till beyond closure and propose measures to address & mitigate these impacts

- The **intent of EIA** in this case should be to:
  - maintain diversity of species
  - maintain the reproductive capacity of the ecosystem as a basic resource of life
  - protect human health and quality of life
  - wisely utilize natural resources; effectively and efficiently
- Exploitation should be done in accordance with good international practices and in a safe- environmentally acceptable manner; using best available techniques
- The purpose of EIA guidelines is to direct mining companies' attention to envtal issues at an early stage of mining projects

- Issues-impacting aspects-impacts of mining sector

Issues	Aspects	Impacts
Change in social structure & way of life	Labour	Women & child labour; change in power structure
	Location of project	resettlement
	Employment	Rular-urban migration; slum settlement; conflict between new & old residents; strain on community services; change in land use
Land-use	Mining is area demanding	Conflict with existing land use and land tenure systems
Economy	Mining involves vibrations & blasting	Interfere with other economic activities
Human safety	Mechanical equipments; electric, explosives, dangerous substances; collapses	Injury, disability, death

Human health	Carcinogenic substances (asbestos, quartz dust, nickel dust; radioactive; heavy metals (Pb, Zn)	Central nervous system disorder, acute illness
	Incomplete combustion of coal (CO)	Headache, dizziness, suffocation, death (excess CO)
	Waste (gangue, tailing containing sulfides)	Water and soil contamination
	Noise: mechanical operations & blasting in open pit	Hearing impairment, sleep disturbance, neurotic illness
Pressure on natural resource base	Extraction of: raw materials, water, energy, man power	Unsustainable utilization of natural resources

Water quality	Mine water tailings; non conventional extraction techniques; extraction of gold using mercury; mineral dressing; waste water with oil & other chemicals; Acid mine drainage with heavy metals; washing water for separation with sand, rock chips, explosive residue; runoff water from open pit	Toxic impacts on ground and surface water; eutrophication (Depletion of oxygen in a nutrient-rich body of water by growth of too much plant life, leading to death of animal life); health impacts to human & animals; Impact on other sector: drinking water, irrigation, agriculture
Soil quality	Extraction of sand & gravel from river bed; clearing of vegetation exposes fertile top soil for erosion and lack of organic matter; mining on slopes	Soil erosion and mud flow and flooding of silt over river banks covering adjust soil
Air quality	Dust from blasting & machineries movement; noise, coal dust	Dust; toxic gases; nuisance to settlement near quarry; impact o vegetation & human

Sensitive ecosystem/species	Sites for open pit mining, stock piling, access roads, camp	Disturbance; barriers to migration; dispersal result in isolation & threaten fauna & flora
Introduction of exotic species & pests	Transport introduce pests	Threaten indigenous species
Associated infrastructure	Access roads	Pedestrian & wildlife mortality, need for corridor
historical, cultural or religious landscape	Mining on or near the landscape	Impact on aesthetics & scenic value

Recommendations for environmental management

- Establish environmental management system (EMS) to ensure envtal responsibility
- Sufficient distance from vulnerable natural areas (forest, water resources, historical sites…)
- Knowledge of local, national & international requirements; health & safety regulations
- regulations on mining operations to avoid mining in sensitive locations
- Treatment of hazardous waste products
- Measure for reduction of discharges to the air
- Tailing ponds of adequate dimensions to withstand natural disaster
- Rehabilitation measures upon closure
- Safety zones around open pit mining facilities

- **Dams**, *power generation & irrigation*

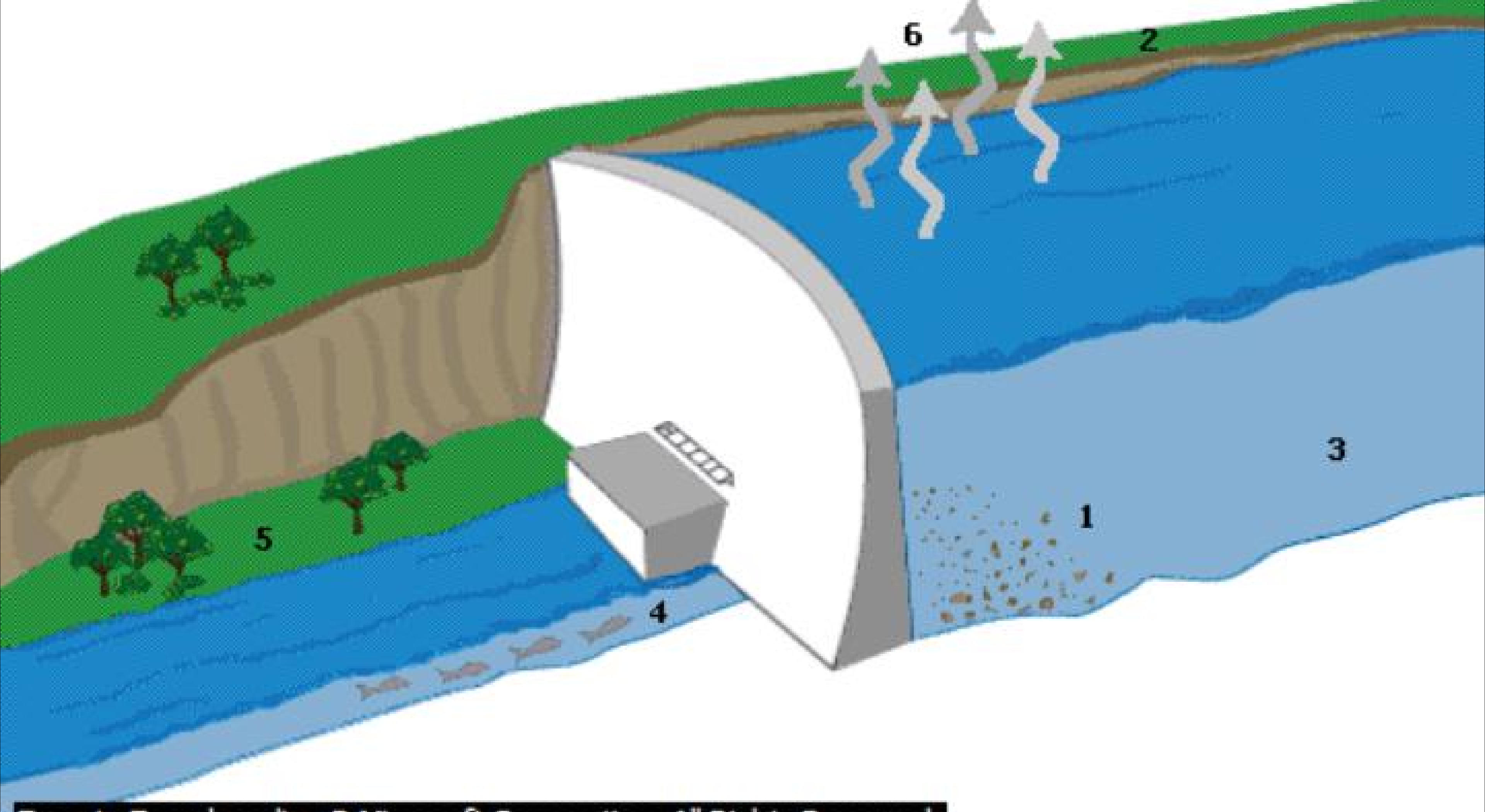
- A dam is a barrier across a river; a very concrete obstacle to the river's natural course and function
- The immediate effects on ecosystem:
  - loss of land, farms, forests, valleys
  - control flow of river & its content
  - depletion of water down stream

Impacts due to the dam	Impacts due to dam operation
● imposition of a reservoir in place of a natural river valley (loss of habitat) ● changes in downstream morphology of riverbed delta due to altered sediment load (increased erosion downstream) ● heavy downstream sediment loading during construction of power plant ● changes in downstream water quality- temperature, nutrient, turbidity, dissolved gases, heavy metal conc., & minerals ●Reduction of biodiversity due to blocking of organisms movement	■ changes in downstream hydrology ■ changes in total flow, extreme high and low flows ■ changes in seasonal flow ■ short term fluctuation (daily or hourly) ■ reduction in riverine/ riparian floodplain habitat diversity

Dams and the Environment

Dams provide water for irrigation and municipal use, help control floods, and produce hydroelectricity. However, damming a river can also have serious environmental side effects. For example,

(1) dams block sediment, which can lead to increased erosion downstream;
(2) reservoirs inundate marshes and previously dry land; (3) cold water released from deep within the reservoir changes the downstream temperature of the river, preventing some types of fish from breeding;
(4) dams can block migratory fish, such as salmon, from reaching upstream spawning grounds;
(5) dams alter flood cycles, allowing riverside vegetation to grow unchecked and disrupting the river's ability to reshape the riverbed; and
(6) water is lost due to evaporation and seepage into the banks of the reservoir, a phenomenon known as "bank storage."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Recommendations for environmental management

- Dam Site selection must consider local earthquake and faulting

- Population resettlement requires careful planning

- Potential uses of dam must be explored, fisheries, irrigation, hydroelectric power and recreation

- Effort must be made to minimize damage or loss of sites of cultural/ historical/ ecological significance

- Negative and positive impacts should evenly be distributed in the society

13.5. Environmental Auditing

- Is a means by which business can assess the EI of their operations
- measurement & evaluation of all inputs & outputs in their production process
- **Objectives:-**

  i. waste prevention & reduction

  ii. Compliance with regulatory requirements

  iii. Environmental information in the public domain

Components of a good Audit

*i. **Data collection:*** identify and measure all input and output
- provide a baseline for comparison against targets for improvement

*ii. **Compliance:*** review and compare a company's activity targets against all relevant regulations, codes of conduct and govtal policies

*iii. **Documentation:*** all aspects of audit to assess progress at a further date and verify envtal performance to staff, regulators & general community

*iv. **Periodic audits***: assess the impacts of new or changed legislation on operations and whether internal targets are being met

Quiz 2

- Give short answers for the following questions

1. What is the cause of an EL-Nino? (one line only)
2. List at least three gases that may enhance the green house effect?
3. The greenhouse phenomena is purely man induced (true/False).
4. List at least two advantages that vegetation contribute for slope stability.
5. What Is the major force causing mass movement/sliding of slope materials?

QUESTIONS: Environmental issues related to mining

1. List all the major environmental impacts of surface mining?
2. List all the major environmental impacts of underground mining?
3. Discuss in detail about the acid mine drainage, AMD process?
4. What are the major impacts of an acid mine drainage, AMD?
5. a mining process starts with prospecting, extraction, processing, utilization and ends with the disposal of old products. Discuss the environmental impacts of each of the mentioned steps in mining?

Quiz 3, <u>10</u>% (Time allotted 25 munities)
Thursday December 9/2010
Name --
ID No--

Choose the letter for the best answer for the following questions

----------Q1. Which one of the following is the biggest freshwater reservoir that can be readily used for human consumption?
a. Oceans
b. Ice caps
c. Groundwater
d. River water

----------Q2. Which one of the following groundwater contaminants has the highest dispersion potential?
a. Immiscible contaminants
b. Microbial contaminants
c. Benzene and other light gases
d. Miscible contaminants

----------Q3. The environmental impact of a mining activity depends on many factors except one of the following
a. mining procedures/type of mining activity
b. rock type
c. size of mining operations
d. none of the above

----------Q4. During the various steps of underground mining for metallic mineral ores, which one of the steps causes the most significant environmental degradation?
a. Extraction
b. Processing
c. Crushing and transportation
d. Using

----------Q5. One of the following is not the principal use of soils in the environment?
a. Medium for plant growth
b. recycling of nutrients and wastes
c. water supply and purification
d. sanitary landfill site

Match the items listed in column A with the letter for the best answer in column B.

A	B
----------1. A possible geohazards in the rift valley	A. Gravity
----------2. Shear strength of slope materials	B. flash flooding
----------3. The main triggering mechanism of landslides	C. Landslide
----------4. Intense rainfall in a short period of time	D. cohesion of slope material
----------5. Source of Arsenic in groundwater	E. Heavy rainfall
	F. Volcanism
	G. Intrusive rocks like granites
	H. Groundwater

Quiz 4, 10%

Q1. How can you prevent creation of waste at source?

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Q2. What is the difference between waste *Recycle* and *Reuse*?

Q3. List the two major disadvantages of a sanitary landfill?

Q4. Carbon dioxide is removed from the atmosphere and added in to the ocean reservoir through two processes, _________ and _______

Q5. List four development challenges in megacities?

Reading assignment

1.Write a one page essay about the green house phenomena. What is global warming?
2.What is Ozone layer depletion? What is the cause of ozone layer depletion (half page only)?

- Submission date: 7 days from the date questions were given.

End of Course