Unit 5

S4 and S5

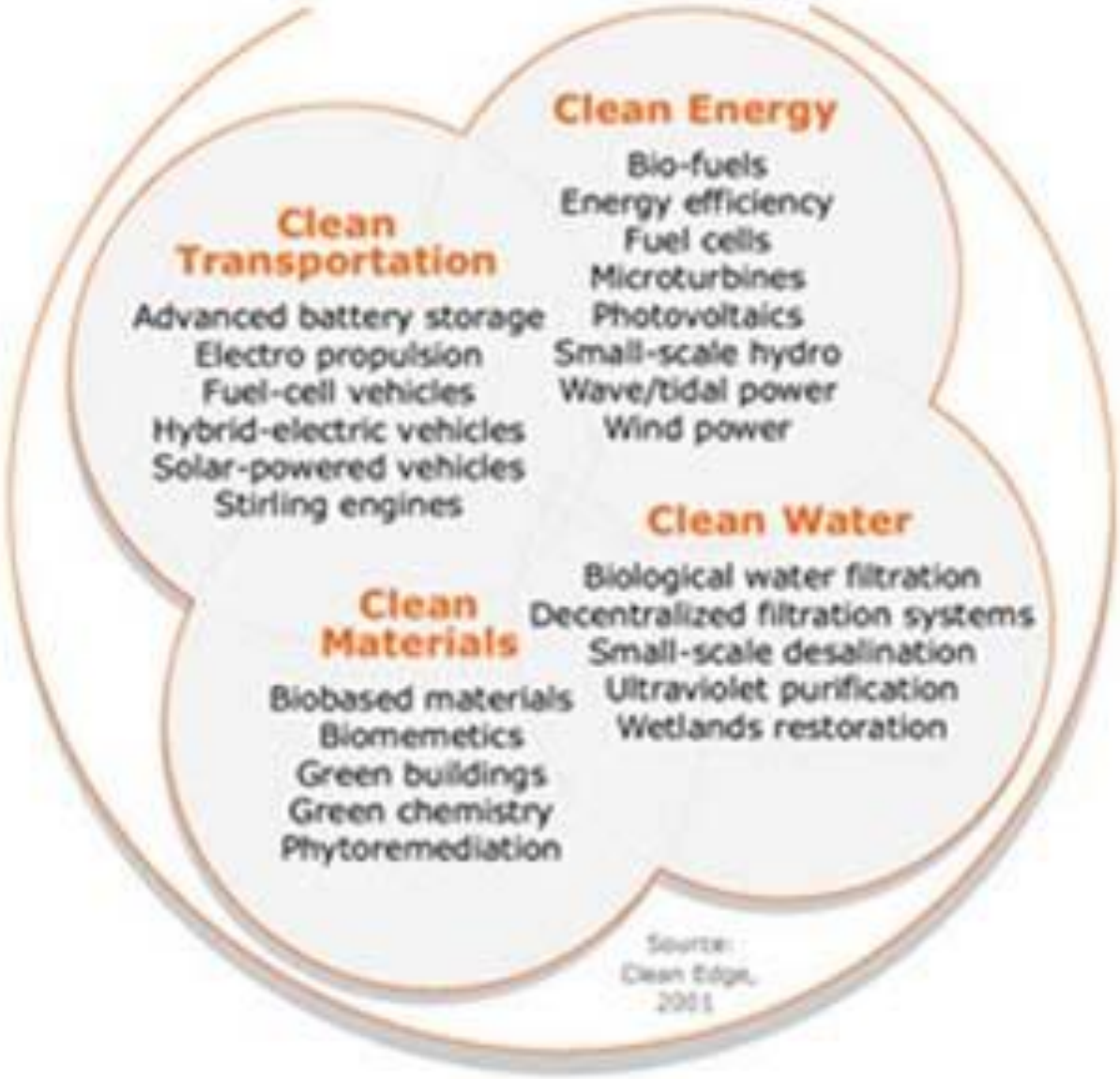
SLO-1 Clean Technology, Biodeisel, compost, biodegradable plastic

SLO-2 Concept of sustainable development

Clean Technology

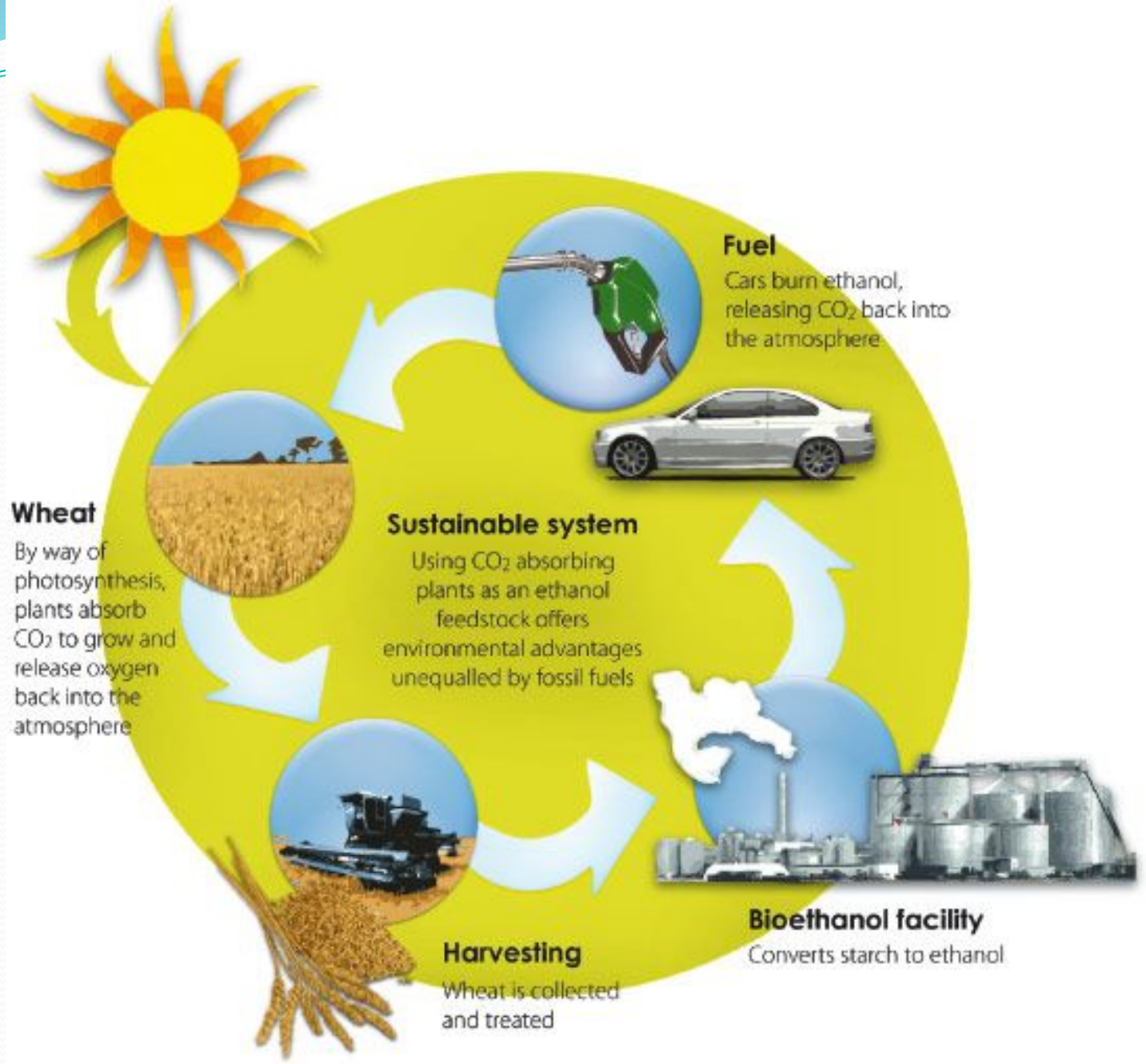
- **Clean technology**, in short cleantech, is any process, product, or service that reduces negative environmental impacts through significant **energy** efficiency improvements, the sustainable use of resources, or environmental protection activities.

Clean Technology



Biofuels

- Unlike other renewable energy sources, biomass can be converted directly into liquid fuels, called "biofuels," to help meet transportation fuel needs. The two most common types of biofuels in use today are ethanol and biodiesel.
- Ethanol is an alcohol, the same as in beer and wine (although ethanol used as a fuel is modified to make it undrinkable). It is most commonly made by fermenting any biomass high in carbohydrates through a process similar to beer brewing.
- Today, ethanol is made from starches and sugars
- Ethanol can also be produced by a process called gasification. Gasification systems use high temperatures and a low-oxygen environment to convert biomass into synthesis gas, a mixture of hydrogen and carbon monoxide. The synthesis gas, or "syngas," can then be chemically converted into ethanol and other fuels.
- Ethanol is mostly used as blending agent with gasoline to increase octane and cut down carbon monoxide and other smog-causing emissions. Some vehicles, called Flexible Fuel Vehicles, are designed to run on E85, an alternative fuel with much higher ethanol content than regular gasoline.


Fuel
Cars burn ethanol, releasing CO_2 back into the atmosphere
Wheat
By way of photosynthesis, plants absorb CO_2 to grow and release oxygen back into the atmosphere
Sustainable system
Using CO_2 absorbing plants as an ethanol feedstock offers environmental advantages unequalled by fossil fuels
Bioethanol facility
Converts starch to ethanol
Harvesting
Wheat is collected and treated

Food security???

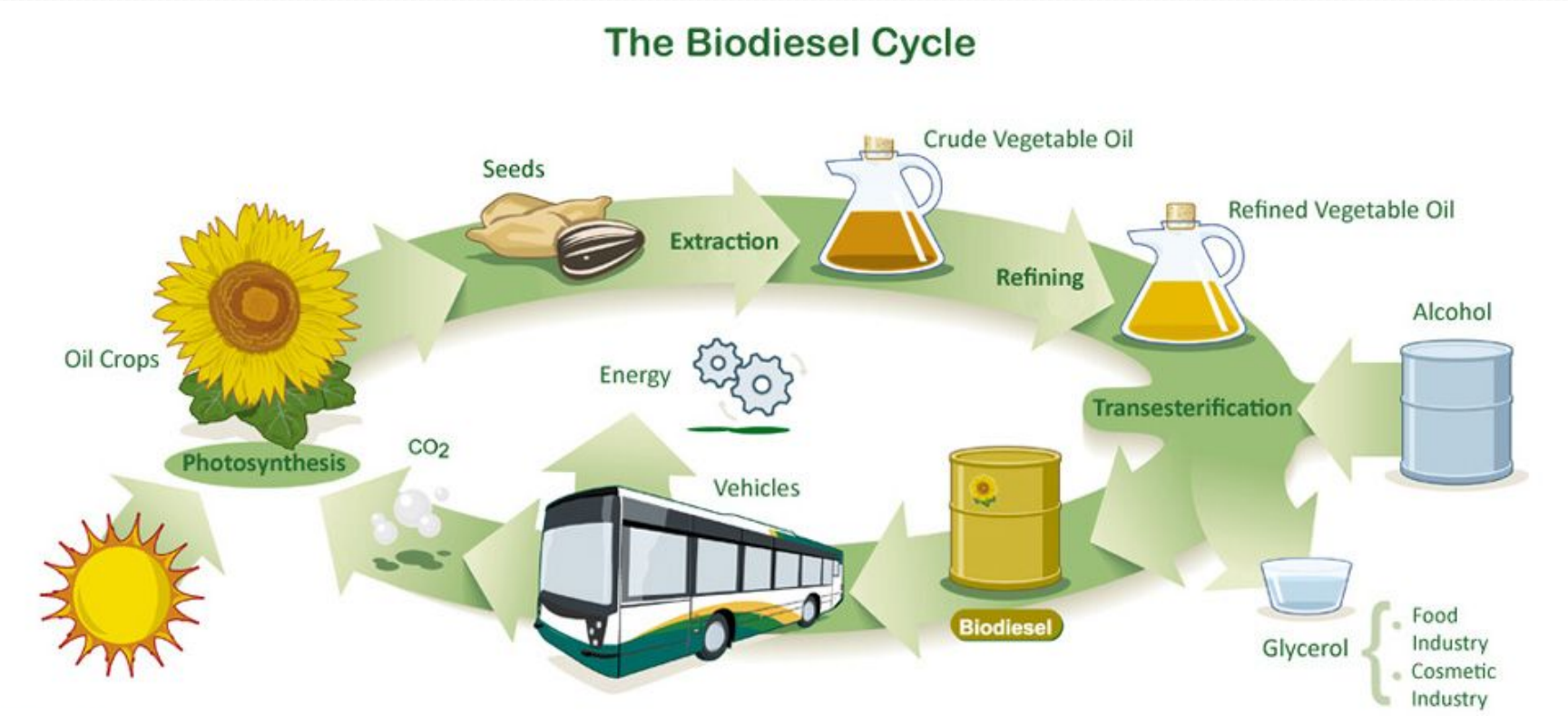
- Biofuel crops increase emissions through land clearance, fertiliser use, and by displacing other crops.
- When millions of hectares of land are switched from food to biofuel crops, food prices rise and food production is displaced, triggering a domino-like chain of events ending in cropland expansion elsewhere, including into the tropical forests of Southeast Asia and the savannas of South America and Africa.
- So, proper policies should be framed for areas that should be used for cultivation of biofuel crops and edible crops not to threaten the food security of any country that cultivates crops for biofuels.

Biofuels can come from a wide variety of sources and can be roughly divided into four categories or "generations:"

- First generation biofuels are made from sugars, starches, oil, and animal fats that are converted into fuel using already-known processes or technologies. These fuels include biodiesel, bio-alcohols, ethanol, and bio-gasses, like methane captured from landfill decomposition.
- Second generation biofuels are made from non-food crops or agricultural waste, especially ligno-cellulosic biomass like switch-grass, willow, or wood chips.
- Third generation biofuels are made from algae or other quickly growing biomass sources.
- Fourth generation biofuels are made from specially engineered plants or biomass that may have higher energy yields or lower barriers to cellulosic breakdown or are able to be grown on non-agricultural land or bodies of water.

Biodiesel

- Biodiesel is a domestically produced, renewable fuel that can be manufactured from vegetable oils, animal fats, or recycled restaurant grease for use in diesel vehicles.
- Biodiesel's physical properties are similar to those of petroleum diesel, but it is a cleaner-burning alternative.
- Using biodiesel in place of petroleum diesel, especially in older vehicles, can reduce emissions.


The Biodiesel Cycle
Crude Vegetable Oil
Seeds
Extraction
Refined Vegetable Oil
Refining
Alcohol
Oil Crops
Energy
Transesterification
Photosynthesis
CO_2
Vehicles
Biodiesel
Glycerol
Food Industry
Cosmetic Industry

- Biodiesel is a liquid fuel often referred to as B100 or neat biodiesel in its pure, unblended form. Like petroleum diesel, biodiesel is used to ***fuel compression-ignition*** engines, which run on petroleum diesel.
- How well biodiesel performs in cold weather depends on the blend of biodiesel. The smaller the percentage of biodiesel in the blend, the better it performs in cold temperatures.

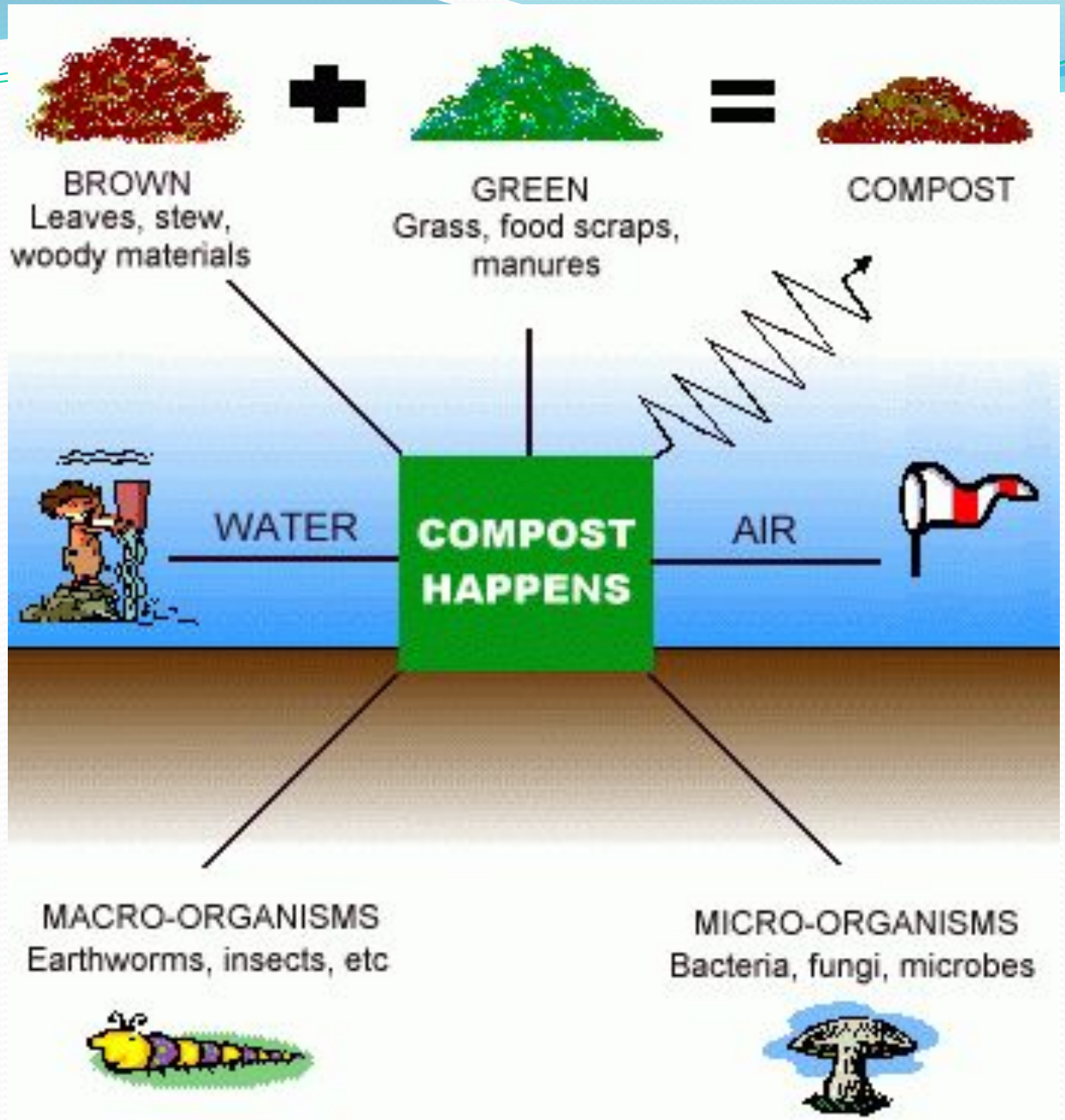
1) Biodiesel is a clean burning renewable fuel made using natural vegetable oils and fats.
2) Biodiesel is made through a chemical process which converts oils and fats of natural origin into fatty acid methyl esters (FAME) through a process called trans-esterification.
3) Biodiesel is intended to be used as a replacement for petroleum diesel fuel, or can be blended with petroleum diesel fuel in any proportion.
4) Biodiesel does not require modifications to a diesel engine to be used.
5) Biodiesel has reduced exhaust emissions compared to petroleum diesel fuel.
6) Biodiesel has lower toxicity compared to petroleum diesel fuel.
7) Biodiesel is safer to handle compared to petroleum diesel fuel.
8) Biodiesel quality is governed by ASTM D 6751 quality parameters.
9) Biodiesel is biodegradable.

Compost

- **Composting** is the process that speeds up decomposition of organic materials by providing ideal conditions for microorganisms to thrive.
- **Compost** is rich in nutrients. It is **used, for** example, in gardens, landscaping, horticulture, urban agriculture and organic farming. The **compost** itself is beneficial for the land in many ways, including as a soil conditioner, a fertilizer, addition of vital humus or humic acids, and as a natural pesticide for soil.

- Composting is a great way to reduce your food waste and contributions to GHG
- Compost is simply decayed organic matter — and "organic matter" is a pretty wide-ranging label. A twig can be organic matter, but so can a banana peel. When you mix a bunch of these items together in a compost pile, they break down naturally into a nutrient-rich fertilizer that helps gardens grow. Green house gas emissions.

- Studies further show that compost can aid in carbon sequestration. When applied to soil, compost potentially functions as a "carbon sink," trapping and containing the element in the dirt. And if the carbon is in the ground, it isn't in our atmosphere, where it can wreak havoc on the planet.


BROWN
Leaves, stew, woody materials
GREEN
Grass, food scraps, manures
COMPOST
WATER
COMPOST HAPPENS
AIR
MACRO-ORGANISMS
Earthworms, insects, etc
MICRO-ORGANISMS
Bacteria, fungi, microbes

Types of Composting

- **Composting** Basics.
- Onsite **Composting**.
- Vermicomposting.
- Aerated (Turned) Windrow **Composting**.
- Aerated Static Pile **Composting**.
- In-Vessel **Composting**.

Biodegradable plastics

- **Biodegradable plastics** are **plastics** that can be decomposed by the action of living organisms, usually microbes, into water, carbon dioxide, and biomass. **Biodegradable plastics** are commonly produced with renewable raw materials, micro-organisms, petrochemicals, or combinations of all three.
- While the words "bioplastic" and "biodegradable plastic" are similar, they are not synonymous. Not all bioplastics are biodegradable.

What plastic is biodegradable?

- One set of degradable plastics are **materials** such as PLA (**Polylactic Acid**) that are unique plastics for which biological degradation potential is part of the nature of the plastic. The second set is **materials** of the standard #1 **PET**, #2 HDPE, #4 LDPE, #5 PP and #6 PS with special degradable additives included.

- **Biodegradable plastics** are very rarely recyclable, and **biodegradable** does not mean **compostable**–so they often up in the landfill. **Compostable** and bioplastic goods can be a better choice than **biodegradable** ones, but often still end up in landfills unless you can compost appropriately.

What are the problems with biodegradable plastics?

- When some biodegradable plastics decompose in landfills, they produce methane **gas**. This is a very powerful greenhouse **gas** that adds to the problem of global warming. Biodegradable plastics and bioplastics don't always readily decompose.

- Biodegradable plastics take **three to six months** to decompose fully. That's much quicker than synthetic counterparts that take **several hundred years**. Exactly how long a biodegradable bag takes to break down depends on various factors, such as temperature and the amount of moisture present.

Concept of **Sustainable development**

- "**Sustainable development** is **development** that meets the needs of the present without compromising the ability of future generations to meet their own needs.“
- The **aim of sustainable development** is to balance our economic, environmental and social needs, allowing prosperity for now and future generations. These include social progress and equality, environmental protection, conservation of natural resources and stable economic **growth**.

- Political **barriers**: Inadequate economic, social and environmental **methods** for policies, plans and projects are the **major barrier** combating the implementation of **sustainable development**.

Concept of sustainable development

Sustainable development is maintaining a delicate balance between the human need to improve lifestyles and feeling of well-being on one hand, and preserving natural resources and ecosystems, on which we and future generations depend.

Why sustainable Development is Important

It's no secret that people are living longer and that the global population is on the rise. In fact, the United Nations projects that there will be more that 10 billion people living on the Earth by the year 2100. This explosion in population is perhaps one of the greatest reasons why sustainable development is so important.

Provide Basic Human Needs(social)

A rising population will also make use of the bare essentials of life such as food, water, and shelter.

Agricultural Necessity

Agriculture will have to catch up with that growing population as well, figuring out ways to feed around 3 billion more people than it currently does

Accommodate City Development(social)

As populations rise, cities will need to become larger to accommodate the influx of new residents.

Control Climate Change

Climate change is another issue that can be at least partially remedied through sustainable development. Sustainable development practices would mandate a lower use of fossil fuels, which are not sustainable and which produce greenhou gases.

Provide Financial Stability(economic) Sustainable development can also produce more financially sustainable economies throughout the world.

Sustain Biodiversity(Environmental) Biodiversity suffers through overconsumption and unsustainable development practices.

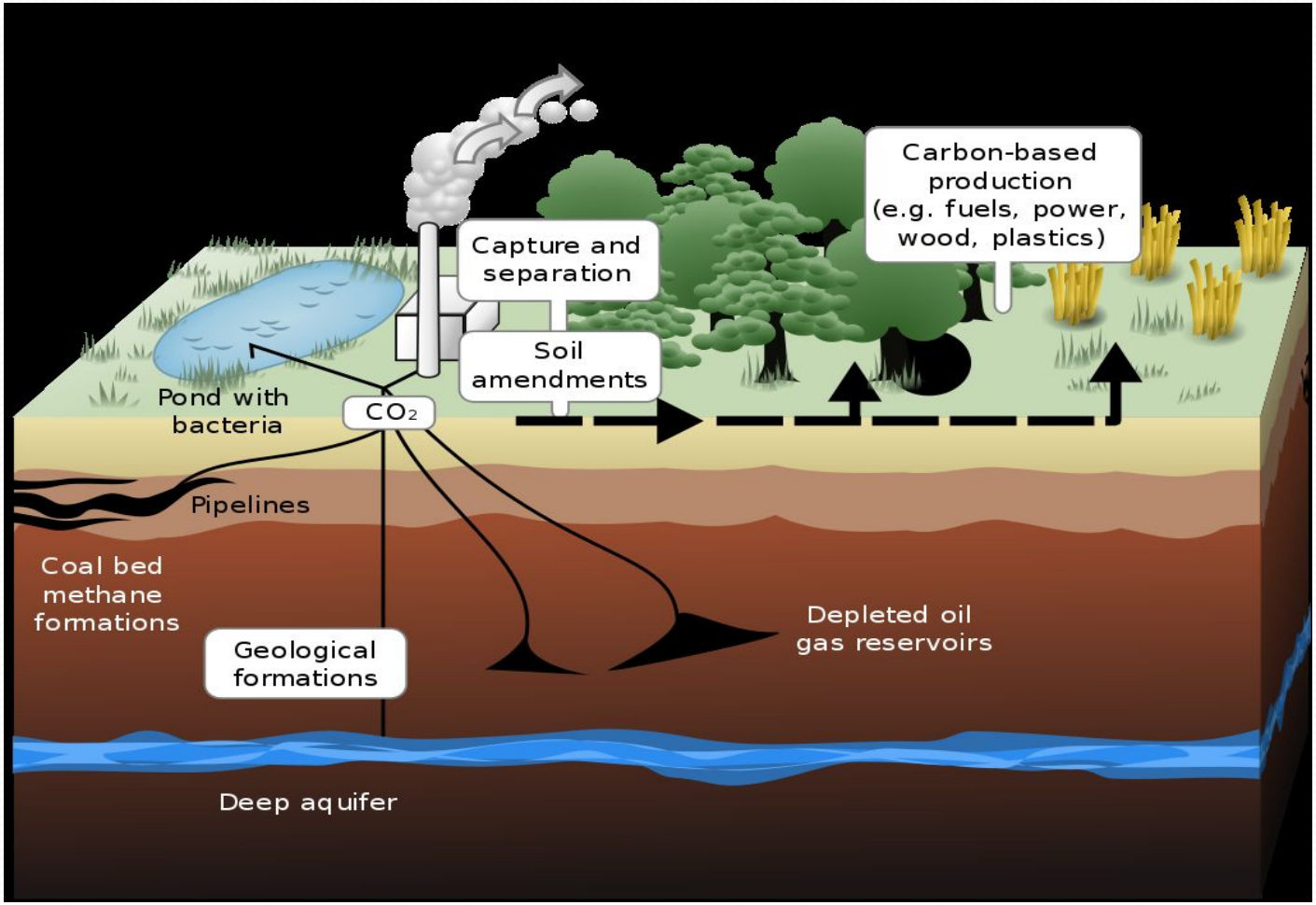
- For example, if unsustainable agricultural practices are used in regard to pesticides, bees and other pollinators could be negatively impacted. Without bees, at least 19 major food crops would suffer and nearly 50% of the food in most grocery stores would be non-existent.

Technology: we are living in a world where almost everything is done technologically. We need sustainable development in managing these resources through recycling and other methods

Concept of carbon sequestration

- **Carbon sequestration** is the process of capturing and storing atmospheric **carbon** dioxide. It is one method of reducing the amount of **carbon** dioxide in the atmosphere with the goal of reducing global climate change.

Schematic showing both terrestrial and geological sequestration of carbon dioxide emissions from heavy industry, such as a chemical plant



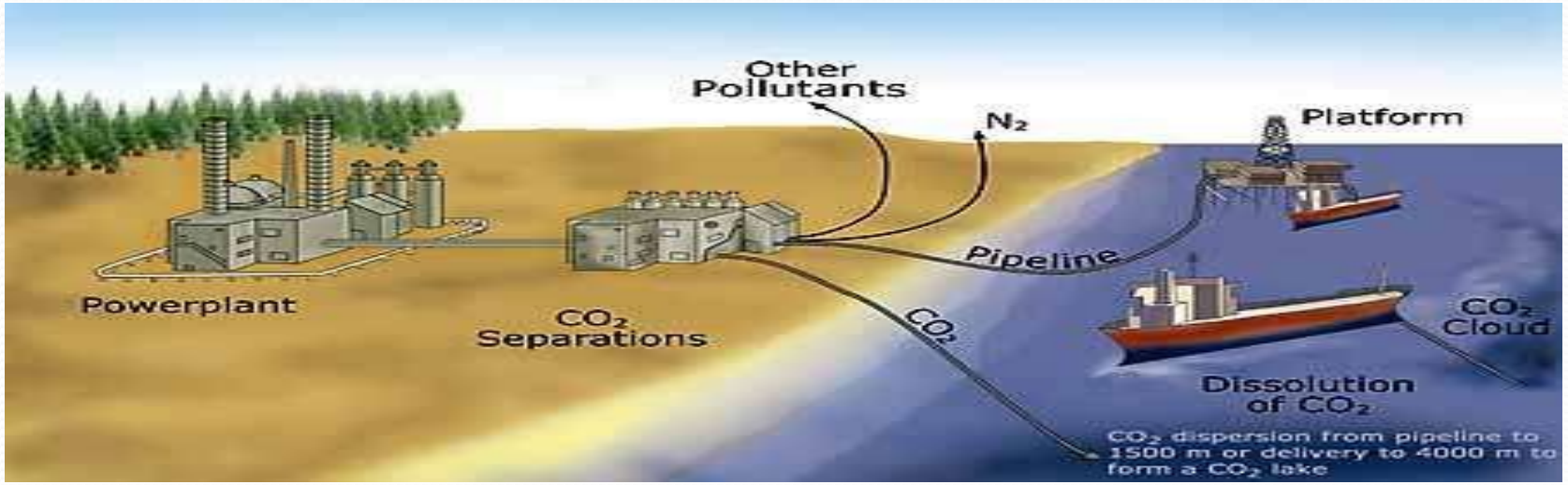
Ways that carbon can be sequestered

1. Geological sequestration : Underground
2. Ocean Sequestration : Deep in ocean
3. Terrestrial Sequestration : In plants and soil

1.Geological sequestration

- Geologic Storage involves capturing anthropogenic CO_2 before it enters the atmosphere and injecting it into underground formations. Once CO_2 is injected deep underground (typically more than 800 meters) it is trapped in minute pores or spaces in the rock structure. Impermeable cap rocks above the storage zones act as seals to ensure the safe storage of CO_2.

2.Ocean sequestration



- Carbon is naturally stored in the ocean via two pumps, solubility and biological and there are analogous man made methods, direct injection and ocean fertilization, respectively.
- At the present time, approximately one third of human generated emission are estimated to be entering the ocean.

3.Terrestrial Sequestration

The process through which CO_2 from the atmosphere is absorbed naturally through photosynthesis & stored as carbon in biomass & soils.

- Terrestrial (or biologic) sequestration means using plants to capture CO_2 from the atmosphere and then storing it as carbon in the stems and roots of the plants as well as in the soil.

- Terrestrial sequestration is a set of land management practices that maximizes the amount of carbon that remains stored in the soil and plant material for the long term. No-till farming, wetland management, rangeland management, and reforestation are examples of terrestrial sequestration practices that are already in use.

Methods that enhance carbon buildup in biomass and soils include:

- Adopting conservation tillage
- Reducing soil erosion
- Minimizing soil disturbance
- Using buffer strips along waterways
- Enrolling land in conservation programs
- Restoring and better managing wetlands
- Eliminating summer fallow
- Using perennial grasses and winter cover crops
- Fostering an increase in forests

CO_2 Capture Technologies

- Pre-combustion
  - In this process, the fuel is pre treated before combustion.
- Post-combustion
  - This process removes CO_2 from the flue gas after combustion has taken place.
- Oxyfuel combustion
  - In Oxyfuel combustion, oxygen, instead of air, is used for combustion.

CO_2 Separation Technologies

The main CO_2 separation technologies that can be applied to isolate the CO_2 from the fuel gas stream prior to transportation.

1. Absorption

A liquid sorbent is used to separate the CO_2 from the flue gas. The sorbent can be regenerated through a stripping or regenerative process by heating and/or depressurization.

2. Adsorption

In contrast to absorption processes which use a liquid absorbent, a solid sorbent is used to bind the CO_2 on its surfaces. Large specific surface area, high selectivity and higher generation ability are the main criteria for sorbent selection.

3. Chemical looping combustion

A metal oxide is used as an oxygen carrier instead of using pure oxygen directly for the combustion as in the case of oxyfuel combustion. During the process the metal oxide is reduced to metal while the fuel is being oxidized to CO_2 and water.

4. Membrane separation

Membranes can be used to allow only CO_2 to pass through, while excluding other components of the flue gas.

5. Hydrate-based separation

Hydrate-based CO_2 separation is a new technology by which the exhaust gas containing CO_2 is exposed to water under high pressure forming hydrates. The CO_2 in the exhaust gas is selectively engaged in the cages of hydrate and is separated from other gases.

6. Cryogenic distillation

Cryogenic distillation is a gas separation process using distillation at very low temperature and high pressure, which is similar to other conventional distillation processes except that it is used to separate components of gaseous instead of liquid.

Carbon sources and carbon sinks

- **Carbon source**
  - A forest is considered to be a carbon source if it releases more carbon than it absorbs.
  - Anthropogenic activities such as the burning of fossil fuels have released carbon from its long-term geologic storage as coal, petroleum and natural gas and have delivered it to the atmosphere as carbon dioxide gas.

Carbon sink

The main natural carbon sinks are plants, the ocean and soil. Plants grab carbon dioxide from the atmosphere to use in photosynthesis; some of this carbon is transferred to soil as plants die and decompose. The oceans are a major carbon storage system for carbon dioxide. Marine animals also take up the gas for photosynthesis, while some carbon dioxide simply dissolves in the seawater.

What is Carbon Credits

A carbon credit is a a market term or generic term for any tradable certificate or permit representing the right to emit one tonne of carbon dioxide or the mass of another greenhouse gas with a carbon dioxide equivalent to one tonne of carbon dioxide.

The Role of Trees & forest in Reducing Atmospheric Carbon.

- Trees it's the Carbon Storage Experts. One half the dry weight of wood is carbon. Trees take in CO_2 from the air in the process called photosynthesis.
- The tree effectively breaks down the CO_2, stores the carbon in all parts of the tree, and releases the oxygen back into the atmosphere. Fast growing trees are, in fact, the most efficient way to sequester atmospheric carbon.

- As forests grow, they store carbon in woody tissues and soil organic matter. The net rate of carbon uptake is greatest when forests are young, and slows with time. Old forests can sequester carbon for a long time but provide essentially no net uptake.
- The main strategies for using forests for carbon sequestration
  - **Active forest management**
  - **Avoided deforestation**
  - **Forest preservation**
  - **Afforestation**

Benefits of Soil Sequestration of Carbon

- Improved soil structure
- Better water use and storage
- Less erosion
- Increased soil fertility
- Improved biodiversity
- Healthier ecology
- Improved agricultural performance.

Challenges in soil carbon sequestration

- Deforestation
- Residue burning
- Conventional tillage
- Imbalanced use of fertilizers
- Reduced inputs of organic matter

Conclusions

- Greenhouse gas concentration in the atmosphere are increasing and the threat of global climate change requires our attention.
- Soil carbon sequestration is an effective tool to sequester atmosphere CO_2 with better practical application than other approaches.
- Soil carbon sequestration provide vast opportunity to sequester carbon in the soil.

- A diversity of agricultural management practices can be employed to sequester more carbon in plants and soil:
  - Crop management.
  - Nutrient management.
  - Residue management and conservation tillage.
  - Agro-forestry.
- Soil carbon sequestration using innovate soil and crop management practices is needed to augment soil carbon storage.
- Combination of different agricultural management practices can enhance soil carbon sequestration.