

Environmental Sciences

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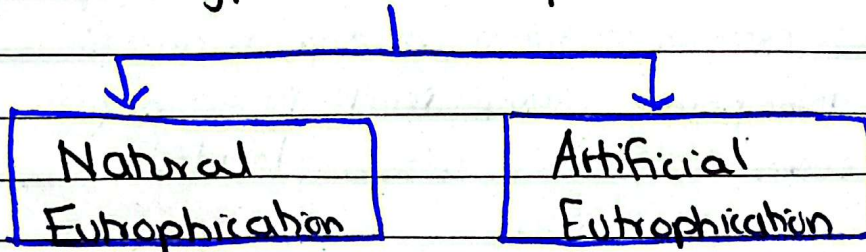
Eutrophication: Types, Process, Controlling Measures

Definition:

"The process by which excessive accumulation of nutrients in a water body results in a bloom of algae (algal bloom) and other plant life, is called as eutrophication."

Types:

Types of Eutrophication



(i): Natural Eutrophication

Eutrophication is the natural ageing of a water body which occurs as a result of accumulation of nutrients, organic matter and sediment buildup over the time period of centuries.

Causes:

- 1: Run-off of surface nutrients from nearby soil as a result of rain, soil erosion causes buildup of nutrients i.e. nitrogen, phosphorus in the water bodies.
- 2: Decay of aquatic plant and animal life over centuries increases the organic matter content of the water.

(ii): Artificial Eutrophication

The process of eutrophication has been sped up due to human interventions in the ecosystem and excessive nutrient buildup as a result of anthropogenic causes results in eutrophication phenomena occurring within decades instead of centuries.

Causes:

1: Agro-fertilizer run-off: Nitrogen and phosphorus fertilizers used for agriculture process ~~have~~ run-off through rainwater and floods into water bodies. This nutrient rich water results in algal blooms.

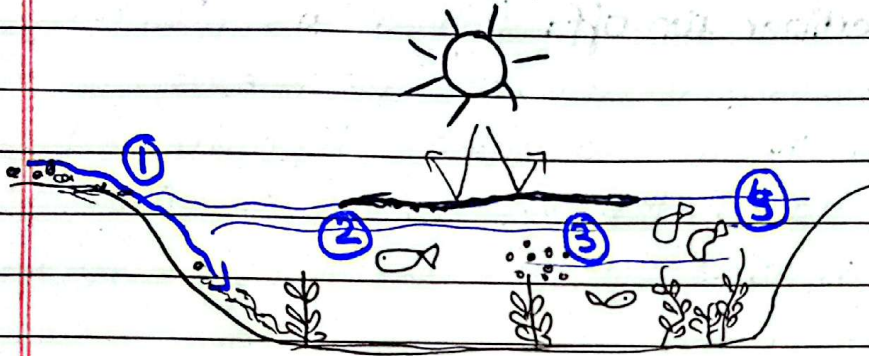
2: Nutrient-rich Industrial effluents:

Nutrients particularly from chemical and fertilizer industry also, upon their mixing with water bodies, lakes results in buildup of nutrients resulting in algal blooms and eutrophication.

3: Improper sewage and municipal waste disposal:

Sewage and municipal waste (organic waste in the form of food leftovers, vegetables and fruits) can become a part of water bodies due to improper disposal measures, decaying of these organic matters creates a bloom of nutrient release into water bodies supporting the growth of aquatic plants i.e algae and phytoplanktons.

Process



1): Run-off of Nutrients and Organic matter from land into water body:

Nutrients in the form of fertilizers (Nitrogen, phosphorus) and organic waste runs off into water bodies from nearby land; due to rain, flood, soil erosion.

2): Formation of Algal Bloom / Layer of Phytoplankton or algae on the surface of water.

These nutrients facilitate the growth of phytoplankton, algae and other plants in the water bodies.

Algal bloom on the surface of water also blocks the entry of sunlight into water bodies depriving aquatic life of access to sunlight required for survival, water temperature maintenance and photosynthesis.

3): Decaying of Dead algae and aquatic plants by microorganisms:

Dead algae and phytoplanktons facilitate the growth of microbes, which decay and decompose the dead organic matter.

In doing so, these microbes absorb a huge amount of oxygen (O_2) depleting water body of its oxygen content.

Hence, the more the growth of phytoplankton and algae as a result of nutrient enrichment, more bacteria to ~~deplete~~ decompose them, hence more oxygen depletion.

4): Destruction of natural water body ecosystem due to oxygen depletion and blocking of sunlight:

Depletion of oxygen and blocking of sunlight affect the balance of water body ecosystem resulting in loss of aquatic plant and animal life, completely destroying the entire ecosystem of water body.

Hence, eutrophication disrupts the natural ecosystem's balance rendering it uninhabitable for aquatic life and drinking purposes.

Controlling Measures

(i): Protection of water bodies from agricultural run-off:

Nitrogen and phosphorus fertilizer runoff from soil should be strictly controlled into nearby water bodies by forming a buffer zone or trench to prevent agricultural run-off into the water body or to keep a safe distance between agri. land and water bodies.

(ii): Mechanical Removal of Algal Blooms and Plant Buildup from water surface:

Algal bloom can be mechanically pulled out from the surface of water to ensure the restoration of water body and access of sunlight underneath.

(iii): Chemical treatment of nutrients and organic matter:

Chlorination and other de-contaminating chemicals can be used to purify water of any excess nutrient and organic matter buildup.

(iv): Oxygenation of water body:

Water bodies can be artificially oxygenated to ensure depletion of oxygen by microbes is countered enough to prevent the loss of aquatic plant and animal life.

(v): Treatment of Industrial Effluents prior to release in water bodies:

Industrial effluents should be subjected to proper treatment before release into environment to reduce nutrient buildup in water bodies.

(vi): Proper Disposal of Sewage and Organic municipal waste:

Ensure proper sewage and ~~dis~~organic waste disposal to prevent contamination of water bodies with waste of any nature which has the potential to enrich the water body of nutrients content.

(b) Greenhouse Gas Emission and Depletion of Ozone Layer

Greenhouse Gas Emission and Global Warming

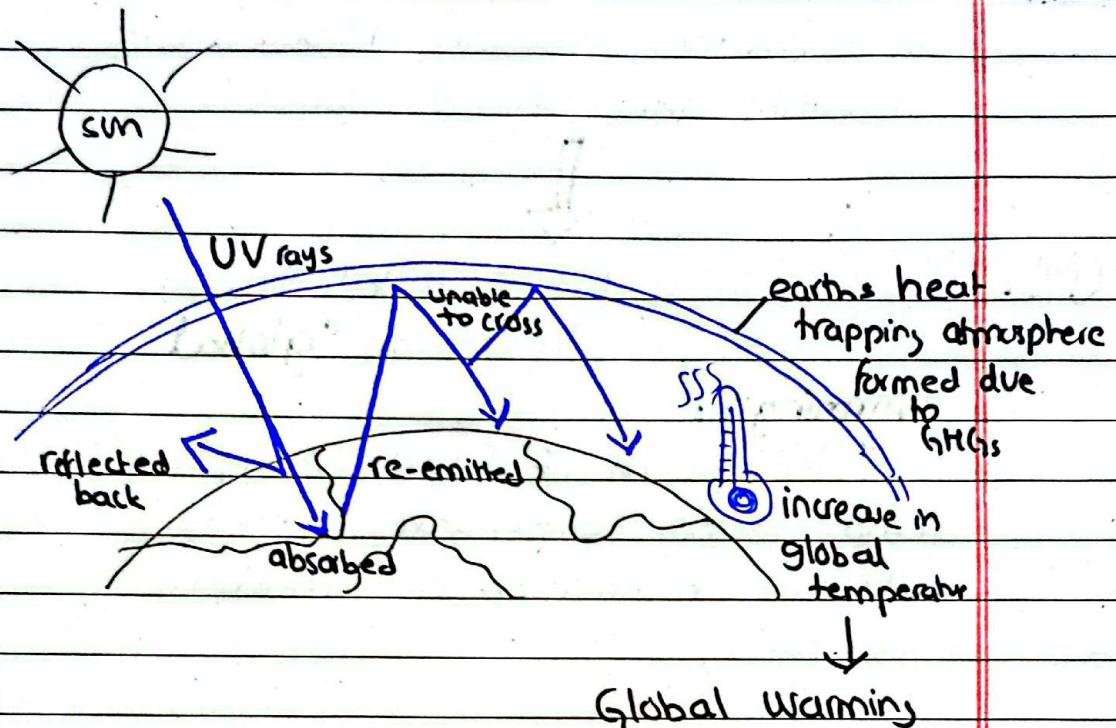
Definition:

"Greenhouse gas emission is the process whereby sun's UV radiation enters the earth surface, some of which is absorbed into the surface of earth, some is reflected back. The surface of earth re-emits this heat as Infrared radiation which when unable to pass through earth's atmospheric layer remains trapped into the earth resulting into a phenomenon called global warming."

Potential Greenhouse Gases (GHG),

1. Carbon dioxide (CO_2)
2. Methane (CH_4)
3. Chlorofluorocarbons (CFCs)
4. Hydrofluorocarbons (HFCs)
5. Water vapours

Process



(i): UV rays from the sun enter into the earth's surface via atmosphere, which majority include UV-B and UV-C.



(ii): Some UV rays are reflected back from earth surface, while some are absorbed by earth's surface. Absorbed UV rays are re-emitted by earth's surface in the form of infrared rays having longer wavelength. These long wavelength IR are unable to pass through heat-trapping atmosphere of earth which contains heat-trapping greenhouse gases.

(iii): Unable to pass through the atmosphere, these Infrared rays are reflected back to earth's atmosphere and surface.



(iv): Resulting in a rise of global temperature, a phenomenon known as "global warming".

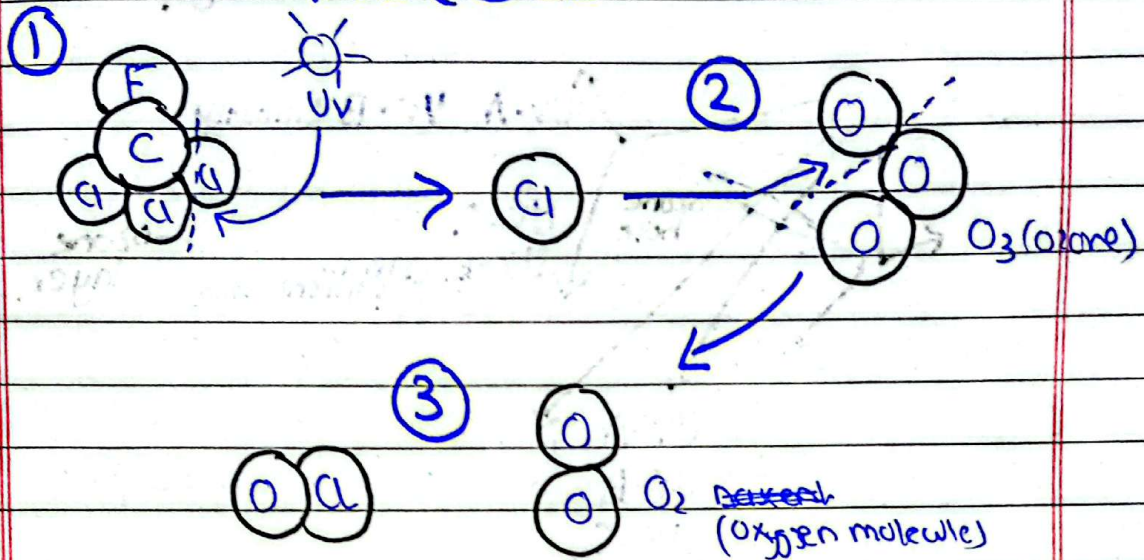
"The increase of Earth's atmospheric and oceanic temperatures due to increase in emission of greenhouse gases."

Depletion of Ozone Layer and Global Warming

Definition:

"The breaking down of ozone (O_3) molecule into oxygen molecule (O_2) and nascent oxygen atom (O) by chlorine atoms, released from chlorofluorocarbons, in the stratosphere of earth, is called as the phenomenon of ozone layer depletion."

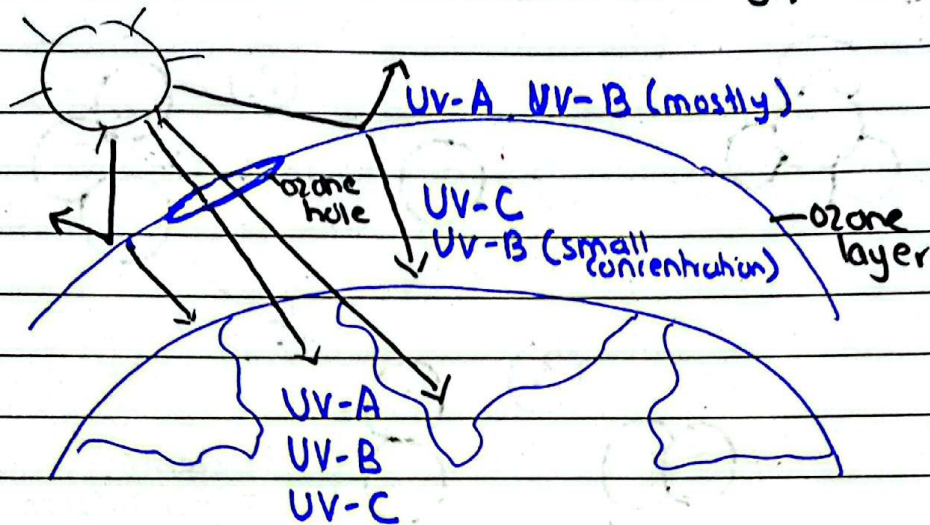
Process



Ozone Depletion

- ① UV rays from sun breakdown Cl atom from Chlorofluoro carbon.
- ② The free chlorine atom (Cl) attacks on the O_3 (Ozone) molecule and removes an oxygen atom from it forming Oxygen atom (O) and Oxygen molecule.
- ③ Oxygen atom separated by chlorine causing ozone molecule, which was sustaining the ozone layer to break. The chlorine atom breaks free of this oxygen atom and continues to break other O_3 molecules, eventually creating a hole in ozone layer.

How Does it Cause Global Warming?



Ozone layer protects earth surface from harmful rays of UV i.e UV-A (extremely harmful), UV-B (moderately harmful, required in a small concentration), UV-C (least harmful).



Depletion of ozone layer is a hole in the protective ozone layer causes UV-rays to enter without any filter causing earth's temperature to rise beyond the levels it can sustain, contributing to the phenomenon called as global warming.

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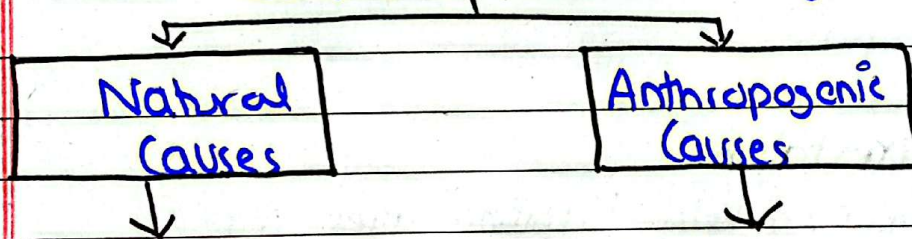
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Climate Change

Definition:

"Climate change is defined as long term shift in global weather patterns, caused due to both natural and anthropogenic reasons, which results in extreme weather, temperatures, seasonal variations."

Causes of Climate Change



- Volcano eruptions
- Variation in earth's orbit
- Solar intensity changes
- Impacts of Asteroids
- Change in Earth's Tectonic plates

- Release of Greenhouse gases
- Deforestation
- Incomplete fossil fuel combustion
- Land degradation and ecosystem disruption

P Possibilities In Countering Climate Change

(i): Global level:

1: Kyoto Protocol (1997):

The ~~big~~ measures introduced in Kyoto protocol i.e. clean development mechanism (CDM), Joint implementation and Carbon emission trading possess the potential to reduce global CO_2 level, if countries decide to act responsibly in reducing their carbon footprints.

2: Reforestation:

Approximately 18 million acres of forest cover is lost every year according to UN-FAO. Hence, initiatives i.e. funding by Greenpeace to start reforestation drives and projects around the world can restore plantation cover, which can help sequester carbon, reducing global warming and the exacerbation of climate change caused due to global warming.

3: Paris Agreement (2015):

Paris agreement signed under COP 21 aims to reduce global temperature 1.5°C before pre-industrial levels. Hence China and Europe's lead of the project, despite USA not being a part of it, signals the potential of success of the agreement if countries contribute responsibly to its binding targets.

4: Shift towards Green Technology and Agricultural Practices:

Post 1990s, world has mainly shifted towards incorporating green technology i.e. environmentally friendly technology and practices in agriculture i.e. energy efficient technology, organic fertilizers, shift towards renewable resources, which will directly help mitigate climate change.

5: Sustainable urban development and Energy efficient building codes:

Shift towards clean, energy efficient sustainable city/urban development i.e. Singapore, Germany's Amsterdam, Copenhagen is a possibility of how efficient building codes, supporting vegetation and reliance on sunlight for major part of the

day can help mitigate climate change.

(ii): Pakistan Initiatives:

1: Pakistan's "National Climate Change Policy" 2018:

Pakistan introduced its climate change policy and act in 2018 to ensure compliance of new development projects and shift towards clean, green and sustainable practices. It involves all the mitigation steps, action plans to restore forest cover, measures to control GHG emissions from industries.

2: Pakistan's "Billion Tree Tsunami" Project:

Billion Tree Tsunami project was a step in the right direction towards contributing to the world efforts towards increasing forest cover and reduce global warming to tackle climate change.

3: Environment Protection Agency - IEE, EIA:

Introduction of Initial examination of environment and Environmental Impact Assessment helps ensure any new development projects comply with climate and environment protection policy of Pakistan.

Hindrances In Countering Climate Change

(i): Global level:

1: USA's withdrawal from Paris agreement:

USA, the world's major economy which has the potential to contribute huge amount to global climate initiative, has stepped down from its climate lead position. This is a major hindrance in climate change efforts as it will encourage more countries to withdraw from Paris agreement and continue to release unchecked emissions in the atmosphere.

2: Lack of compliance by countries to meet their emission targets:

Despite Kyoto Protocol and Paris agreement target setting, countries have repeatedly failed to reduce their greenhouse gas emissions which will continue to exacerbate the climate change phenomenon to a devastating level.

3: Unsustainable development practices and deforestation:

Despite repeated efforts and awareness campaigns, countries continue to cut down trees for urbanization, industrial and agricultural land expansion. This has severely hindered the progress to mitigate climate change.

(ii): Pakistan's level:

1: Policy discontinuity and Implementation Gaps:

Despite having Pakistan environment protection Act (1997), Climate Change Action Plan, Ministry of Climate Change, Pakistan still fails to implement policies to mitigate impacts of climate change effectively.

2: Inefficient technology and Financial constraints hinder mitigation efforts:

Pakistan lacks effective technology to shift its industrial and agricultural practices from traditional, harmful ways to environment friendly clean energy and initiative. Furthermore, financial constraints hinder Pakistan's progress towards achieving a sustainable environment.

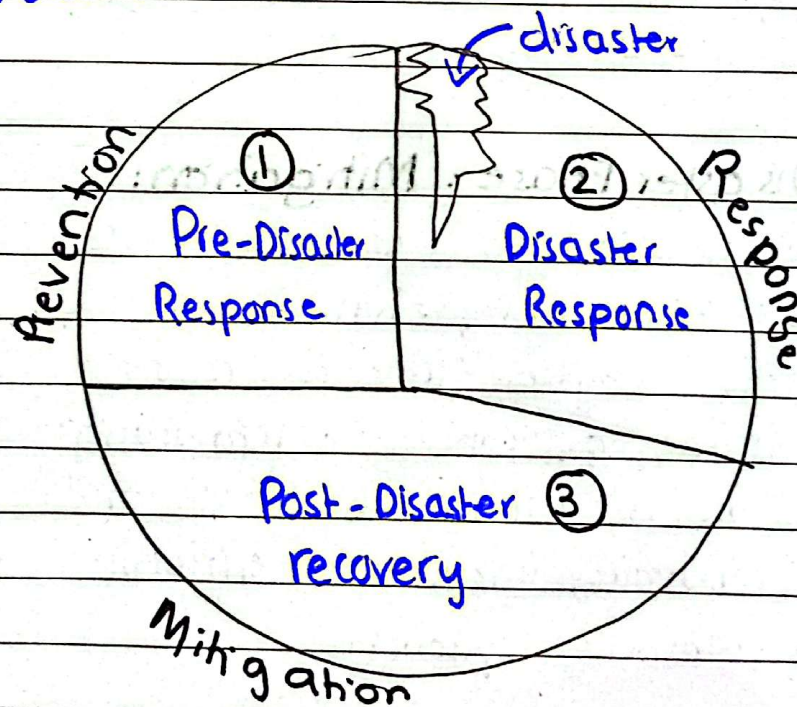
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Disaster Risk Management

Definition:

"Disaster risk management is the process which includes measures taken in pre-disaster phase, disaster response, and post-disaster efforts to manage a disaster and mitigate its impacts."

Steps of Disaster Management Process:



① Pre-Disaster Phase $\Rightarrow$ Prevention

Pre-Disaster phase includes all the initiative taken by a country to mitigate and reduce the harmful impact of disaster i.e. creating

effective policies and measures to prevent the onset of disaster i.e not allowing construction in flood-prone plains, reforestation and plantation measures to control soil erosion, using sustainable irrigation practices to reduce water-scarcity induced drought.

② Disaster Response:

This phase involves measures required at the onset of disaster i.e evacuation, provision of first aid and medical care, control on travel to disaster prone areas, provision of safe camps to disaster affected population.

③ Post-Disaster Phase: Mitigation:

This phase includes reconstruction of damaged infrastructure, rehabilitation of displaced people, efforts to reduce future disaster occurrences i.e reforestation, flood barriers, dams construction and water reservoirs, investing in efficient early warning systems.

Opportunities In Disaster Risk Management For Pakistan

(P): Establishment of Disaster Management Authorities:

NDMA $\Rightarrow$ National Disaster Management Authority

PDMA $\Rightarrow$ Provincial Disaster Management Authority

DDMA $\Rightarrow$ District Disaster Management Authority

In 2007, NDMA was established as a federal level authority and subsequently PDMA and DDMA were established to manage disasters from top-down approach method. The establishment of proper disaster management authority enables Pakistan to take organized steps towards effective disaster management.

(ii): Receiver of Funds for Climate Change Mitigation Under Paris Agreement:

Pakistan being among countries most vulnerable to climate change is a potential receiver of climate fund. Under COP-30, it has been decided that globally \$100 billion ~~de~~ will be allocated annually to help climate affected vulnerable countries take initiatives to mitigate climate induced disasters. Pakistan can utilize these funds for efficiently mitigating climate change and enhancing its disaster management capacity.

Hurdles In Disaster Risk Management

(i): Inefficiency and Inability of Provinces to manage disasters under PDMA and DDMA:

After 18th amendment, disaster management became a provincial matter. But floods of 2022 and 2025 have proved their incapacity to mitigate and reduce disaster risks. This is a major hurdle for Pakistan.

(ii): Financial Constraints:

Financial constraints continue to reduce the ability of disaster management authorities to ensure their capacity building and improve their risk management capacity.

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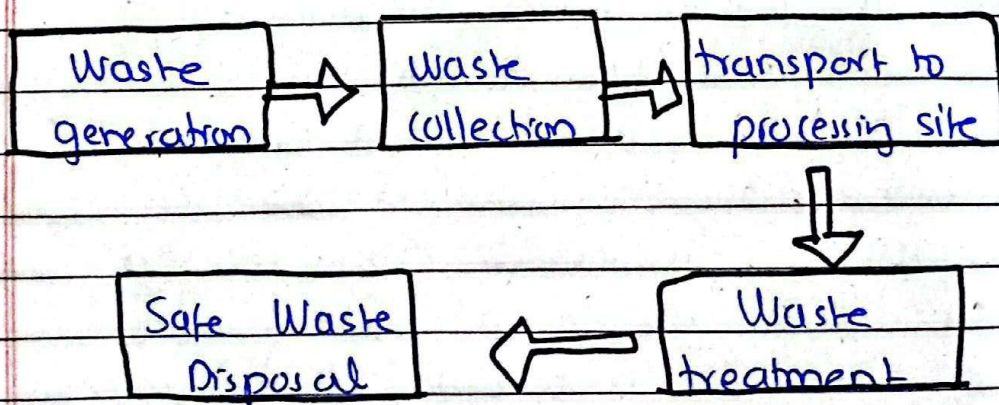
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Solid Waste Management

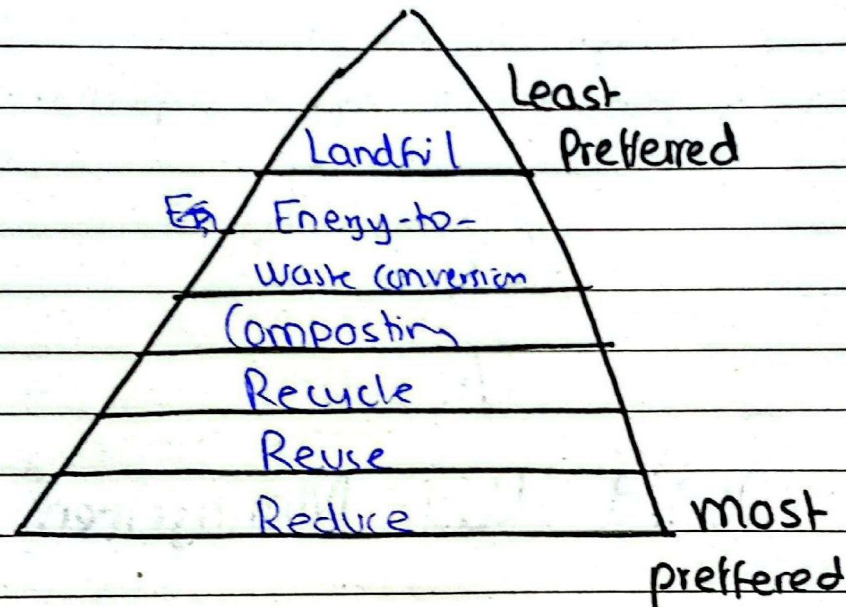
Definition:

"Solid waste management is the process which involves the collection, transport, treatment / processing and disposal of solid wastes in a safe, sustainable manner."

Procedure:



Methods for Solid Waste Management



Pakistan National Solid Waste Management Policy - 2022

Pakistan's national solid waste management Policy of 2022 aims to shift from traditional approaches, which majorly relied on landfill and incineration to more preference to waste reduction, reduce, reuse, recycle and recovery practices to ensure safe environment and health measure.

(i): **3-R approach: Reduce, Reuse, Recycle:**

Pakistan in its policy has decided to shift towards an approach which prioritizes waste reduction at its source by citizens and industries taking responsibility to reduce unnecessary consumption patterns, re-use their waste if it can be managed and recycle Plastic bottles, copper cables etc.

(ii): **Institutional Framework:**

Under ministry of CC an institution will be set up to ensure compliance of waste management policy by all stakeholders.

(iii): **Public-private cooperation:**

The encouragement of cooperation among public sector and waste management municipal authority and private (formal NGO, and informal) sector to ensure comprehensive approach towards waste management.

(iv): **Circular economy - an approach to resource regeneration:**

Instead of throwing away useful resources, they can be reused to extract raw materials instead of again scraping off.

raw materials from their sources. This policy emphasizes circular economy approach to save time and money and resources.

(V): Public and Stakeholder responsibility:

Policy highlights the responsibility at the end of waste generator to take efforts to reduce and reuse as much waste as can be done to reduce burden on environment.

(Vii): Waste Segregation at Source.

Proper waste segregation by source of waste (generator) into recyclable, biodegradable and hazardous waste can ensure effective waste disposal. This policy highlights the responsibility of waste generator to ensure waste segregation effectively.

(Vii): Sustainable Finance Mechanism:

Policy highlights the needs to establish generation and allotment of sustainable funds to manage waste and ensure safe waste disposal.

(Viii): Waste management Action Plan:

A comprehensive action plan by Ministry of Climate Change to address

the concerns, future prospects, funds allocation, legal framework establishment to oversee waste management.

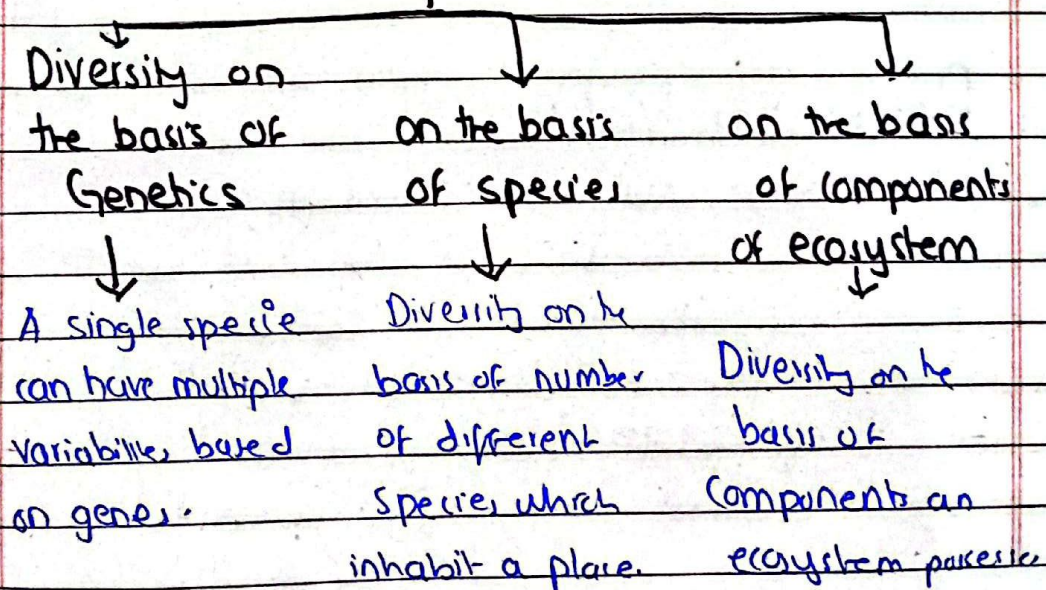
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Biodiversity: Value, Cause & Effects of Biodiversity Loss

Definition:

"The variability of living organisms and the habitat and ecosystem they are part of is termed as biodiversity."

Types



Value of Biodiversity

(i): Productive Value:

Biodiversity i.e. plant, animals varieties, provide food, medicines, livelihood, wood, raw materials for production and manufacturing.

(ii): Regulatory Value:

Water bodies and its ecosystem help maintain water cycle, microbes and plants i.e. leguminous plants help maintain nutrient cycle, plants and forest cover, help maintain atmospheric CO_2 levels, animal species help regulate ecosystem balance i.e. bees help in pollination, birds help in pollination by dispersing seeds, hence each component of ecosystem contributes significantly to sustain environment.

(iii): Protective Value:

Ecosystem biodiversity helps provide protection in multiple ways. Forest cover helps prevent soil erosion and flood intensity, variety of plants contribute variety of food and medicinal options of raw materials to protect humans from adverse health.

impacts.

Causes of Biodiversity Loss

(i): Habitat Destruction:

Destruction of habitat for land use for urbanization, industrialization and agricultural land expansion impacts biodiversity.

(ii): Pollution:

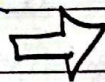
Water pollution → impacts aquatic life both plants and animals

Air pollution → disrupts animal life leading to migration and damage to plants

land pollution → damages crops and microbe population

(iii): Climate change:

Change in weather patterns, destruction of habitats due to climate induced disaster, extreme temperatures, drought, floods



Migration of species from one place to another but inability to adapt to new place i.e. eventual loss of biodiversity

(iv): Over-exploitation:

Over fishing, over-grazing, over-hunting results in extinction or endangerment of species disrupting ecosystem's balance and loss of biodiversity.

(v): Habitat Fragmentation:

- Inability of biodiversity and species to adapt to changing habitats → loss.
- More exposure to hunters and poachers increases vulnerability of species → loss
- Inbreeding among species due to fragmentation of habitat → loss of genetic variability and eventually extinction of species

Effects of Biodiversity Loss

(i): Ecosystem Imbalance:

Loss of species from ecosystem results in loss of that specific function in the ecosystem that species was supposed to perform eventually resulting in disruption of ecosystem.

(iii): Loss of Ecosystem Service:

Food, livelihood, medicine, raw material that the specie was supposed to provide disrupt the service of ecosystem, human benefit from.

(ppg): Loss of one specie results in loss of specie dependent on it - a vicious cycle of biodiversity loss:

Loss of a producer or primary consumer organism can disrupt the entire food chain and will eventually result in loss of secondary, tertiary consumers as well which were dependent on them.

(iv): Climate change:

Loss of plant species crucial to sequester carbon can exacerbate atmospheric CO_2 levels, thus resulting in climate change and its adverse impacts.

(v): Disruption of Nutrient cycle and Water cycle:

These cycles are crucial to sustain environment. However, with the loss of key biodiversity components the entire cycle collapses resulting in disruption of ecosystem.

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(A): Food Insecurity

Definition:

"The lack of access to basic food sources and nutrients due to drought, water scarcity, famine, war, floods or other natural and anthropogenic disaster is called as food insecurity."

Threats to Agriculture Posed by Global Warming

(i): Reduced Yield:

Climate directly impact the crop yields due to climate-induced uncertainty in weather patterns. Warming and excessive day time temperatures can directly result in damage to crops reducing their yield.

(ii): Increased Intensity of Floods, Droughts:

Global warming has exacerbated climate change and with it floods and droughts have become more frequent and more intense.

These disasters poses significant threat to yield and can result in crop damages before maturation.

(iii): Increase In Crop Pest Diseases:

Climate and global warming changes have exacerbated pest-led diseases caused in crops making them more vulnerable, since these crop pests thrive in high temperatures.

(iv): Water Scarcity:

Global warming is reducing water table contents and ground water levels due to increase in evaporation. This has led to significant crop damages and then failure to receive adequate water.

(v): Threat to Beneficial Crop microbes due to high temperature:

Extremely high temperatures and persistent heat waves impact the beneficial and symbiotic microbe populations directly impacting crop growth and reducing crop yield, directly contributing to food insecurity.

Measures To Tackle Global Warming-Led Damage To Agricultural Field

(i): Climate-Resilient Seeds:

Many biotech firms have developed seeds which produce yield majorly resilient to extreme weather change, and intense periods of heat waves.

(ii): Drip-sprinkling to ensure water provision to crops and conservation of water.

Shift from flood irrigation to drip sprinkling method can reduce the impact water scarcity has on crop yield and will conserve ~~water~~ ^{water} for future yields.

(iii): Rainwater Harvesting to Tackle with droughts:

Water scarcity can be addressed by harvesting rainwater to ensure provision of water at all times. This will reduce the impact drought have on crops.

(IV): Agro-Faestry Practices:

Planting trees with crops will reduce the intensity of water flow and minimize the damage it has on crops. It will also help prevent soil erosion.

(B)

Environmental Impact Assessment (EIA)

Definition:

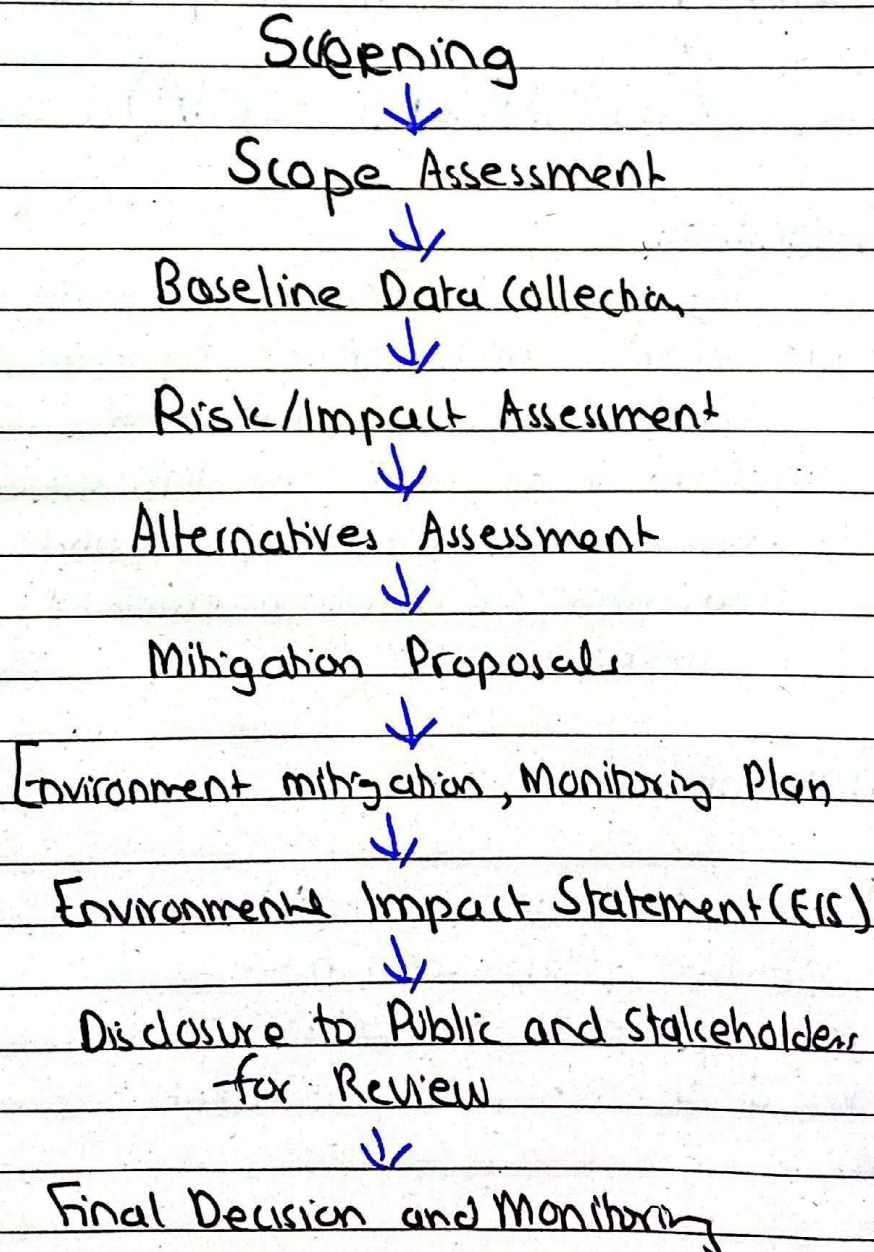
"The process to assess the social, environmental and economic impacts of a developmental impacts before initiating it, to ensure compliance to environmental protection policy and action plans is known as environmental impact assessment."

Benefits:

- (i): Ensures compliance to environmental protection policies and actions
- (ii): Ensures protection and sustainable use and development of environment.

- ciii): Reduces cost implications in case the project would be vulnerable to environmental disasters in the future.
- (iv): Ensures involvement of public and all stakeholders in decision making process.

Process of EIA



(P): Screening:

To determine whether the process requires EIA or not or if mitigation approaches can solve the issue beforehand.

(PP): Scope of Project:

Impacts are assessed and respective teams are established to find solutions to impacts and collection of data.

Terms of reference (TOR) is decided.

(iii): Base line Data collection:

Data about social, economic, environmental, resources, impact, losses are collected about the project by respective teams and managers.

(iv): Impact Assessment:

Scale, Duration, extent, magnitude of impacts are assessed to understand the gravity of situation and costs the mitigation efforts might require can be roughly estimated.

(V): Assessment of Alternatives:

The assessment of potential alternative to reduce impacts such as reduce, compensation, restore is done to select and avail other

available options.

(vi): Mitigation proposals:

This includes measures to reduce impact, find alternate routes, compensate vulnerable, affected stakeholders, restore the site after completion or replace the site with a similar location.

(vii): Environment mitigation and monitoring Plan:

It includes comprehensive plan on how to address the impacts and what efforts are being opted and what will be the possible outcomes. What monitoring and evaluation strategies will be employed.

(viii): Environmental Impact Statement (EIS),

This is the final report to be submitted for review and includes:

- Executive summary
- Legal Framework and Policy
- Environment description
- Project description
- Environmental Impacts
- Mitigation and alternatives
- References List

(IX): Disclosure to Public and Review by Authority (EPA):

Public and EPA reviews all documents attached and ensures compliance with legal framework after which project is either approved or rejected or sent again for corrections.

(X): Monitoring and Evaluation:

If project is approved, it will be monitored regularly by EPA to ensure compliance with FIS provisions and recommendation measures.
