A Green Future in the Digital World – FitDIGIT

2022-1-FR01-KA220-SCH-000084947

Project Result 2

Climate change and its impact on animal lives in forest and water

Authors: Bağarası Hürriyet İlkokulu

Contents

What is Climate Change? 3
Biosphere Integrity..7
Climate Change 11
Newly Developed Materials 14
Ozone Depletion 16
Aerosols 18
Ocean Acidification 23
Deforestation 25
Nitrogen and Phosphorus Pollution 26
In Conclusion..28
What Can Be Done to Prevent Climate Change?..31
Climate Change and E-Coding Curriculum..35
Effects of Climate Change on Forests..40
E-Coding Curriculum: Effects of Climate Change on Forests 43
Module 1: Basics of Climate Change and Forest Ecosystems 43
Module 2: Impacts of Climate Change on Forests..43
Module 3: Conservation and Sustainable Management of Forests..44
Climate Change to Waters Effects..46
What can be done to reduce the impact of climate change on waters?..50
E-Coding Curriculum: Effects of Climate Change on Water..54
Week 1: Climate Change and Water Resources 54
Week 2: Temperature Rise and Drought..55
Week 3: Floods and Flooding 56
Week 4: Sea Level Rise and Coastal Erosion..57
Week 5: Water Quality and Ecosystems..58
Week 6: Adaptation and Sustainable Water Management..59

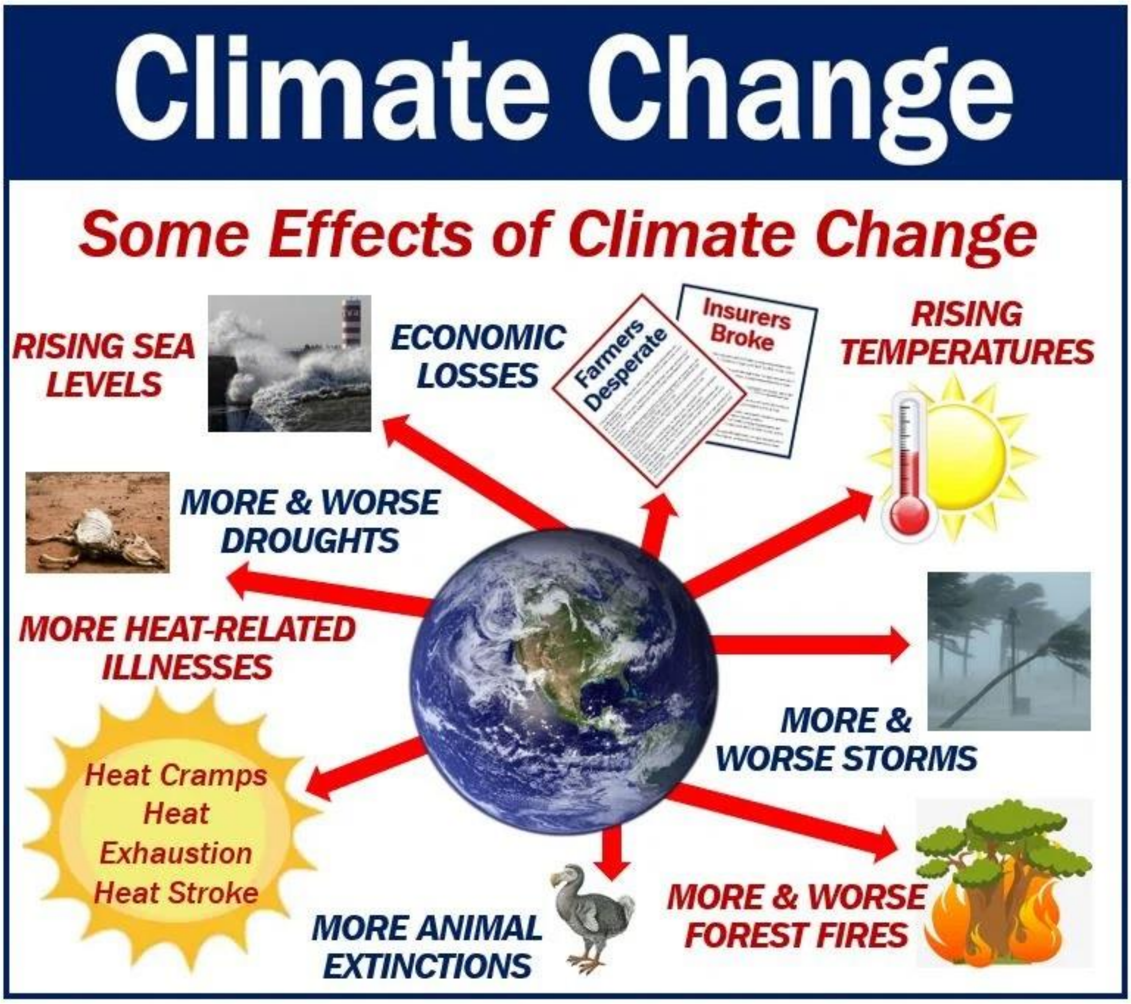
What is Climate Change?

Climate change is the observable and measurable alteration of Earth's general climate conditions over extended periods. These changes are often associated with increases in the concentration of greenhouse gases in the atmosphere. Climate change affects Earth's ecological balance and natural systems alongside alterations in temperature, precipitation, winds, and other meteorological factors. It is linked not only to natural processes such as volcanic eruptions and variations in solar radiation but also to human activities, including the combustion of fossil fuels, deforestation, and industrial activities, which release greenhouse gases into the atmosphere. Consequently, climate change can result in a range of impacts such as rising temperatures, sea-level rise, and increased frequency of extreme weather events, significantly affecting human life, the economy, and ecosystems.

Since the end of the last ice age approximately 11,000 years ago, there has been little significant change in environmental and climatic conditions until human activities gradually began to disrupt nature. Today, it is suggested that a new geological epoch called the Anthropocene has begun, marked by evident human influence on Earth's geology and ecosystems, following the conclusion of the Holocene period that started after the last ice age. Scientific studies are even underway to define the onset of the Anthropocene.

Until about 200 years ago, humans lived in a relatively empty world. Population was low, and natural resources were abundant. When local conditions deteriorated, it was easy to migrate to more hospitable areas. However, in the last two centuries, significant scientific and technological advancements have vastly improved public health, leading to a rapid increase in the global human population. We now inhabit a crowded Earth, and avoiding the environmental and climate issues we cause is no longer as straightforward. Moreover, predicting the ultimate consequences of human-induced changes is challenging. Necessary steps must be taken to ensure that natural conditions remain within safe limits; otherwise, there may be destructive consequences for human societies.

In 2009, a group of researchers published an article defining nine planetary boundaries that should not be crossed to sustain human societies as they have been in the distant past. These boundaries encompass climate change, biosphere integrity, ozone depletion, ocean acidification, nitrogen and phosphorus pollution, deforestation, freshwater depletion, atmospheric aerosols, and synthetic chemicals. When the initial article was published, data was scarce, and quantitative values for all boundaries had not been established. However, over time, numerous studies have been conducted. In a recently published article, quantitative criteria were established for all categories for the first time. The results indicate a deteriorating trend in all but one category.



Biosphere Integrity

The term biosphere refers to the part of the Earth where living organisms reside. Interactions between the Earth and biosphere play a crucial role in regulating environmental conditions. The primary factor enabling the biosphere to fulfill its function is genetic diversity. Therefore, when assessing the integrity of the biosphere, it is essential to consider both its planetary function and genetic diversity.

In the past, planetary boundaries related to biodiversity were associated with the rate of species extinction. While obtaining precise numbers regarding the rate at which species disappeared in the past was challenging, today, it is estimated that the rate of species extinction may be tens or even hundreds of times higher than the average over the past ten million years.

It is believed that the biosphere currently hosts approximately 8 million plant and animal species, with around one million of these species facing the threat of extinction. Within the last 150 years, the genetic diversity of plant and animal species may have decreased by more than 10%.

Regarding genetic diversity, a boundary that should not be exceeded is defined as ten extinctions per million species per year. In other words, the ratio of the number of species lost annually to the total number of species should not exceed one in a million. Even the most optimistic estimates suggest that this ratio exceeds one in a hundred thousand today.

The functionality of the biosphere is closely linked to primary production (the flow of matter and energy provided to the biosphere by photosynthesis). To maintain functionality, it is crucial to consider the proportion of primary production that humans utilize.

In the case of terrestrial primary production, scientific studies indicate that the Holocene average is approximately 55.9x10^9 tons of carbon per year, with very little fluctuation. Annual fluctuations do not exceed 1.1x10^9 tons of carbon per year. Analysis suggests that primary production around 1700 was close to Holocene values, with potential natural net primary production around 56.2x10^9 tons of carbon per year. However, considering land use changes, this value decreases to 54.7x10^9 tons of carbon per year. By 2020, due to excessive accumulation of carbon dioxide in the atmosphere, potential natural net primary production could have increased to 71.4x10^9 tons of carbon per year. However, due to increased global land use, net primary production remained at 65.8x10^9 tons of carbon per year.

The share of primary production that humans utilize encompasses both harvested agricultural production and the alteration (mostly reduction) of net primary production through activities such as agriculture, afforestation, and animal grazing. It can be calculated based on pre-Industrial Revolution Holocene averages or current potential primary production values. However, the current increase in potential primary production is largely due to the excessive accumulation of carbon dioxide in the atmosphere, and to mitigate the effects of global warming, the excess production should not be harvested but preserved. Therefore, it is considered more accurate to calculate the share of primary production that humans utilize based on pre-Industrial Revolution Holocene averages. According to researchers, a safe value for the share of primary production that humans utilize could be 10%. Exceeding 20% of this value is considered dangerous. In the early Holocene, humans' share of primary production was around 2%. Today, this ratio has increased to the 30s. It is noted that the danger limit began to be exceeded in the late 1800s.

Humans meet their needs for food, clothing, animal feed, etc., from primary production and will continue to do so. An increase in net primary production is necessary for a more sustainable future. It is estimated that the Earth can safely feed ten billion people, but scientific and technological advancements are needed to achieve this.

Climate Change

Climate change, one of the greatest environmental challenges of our time, stems from the excessive increase in greenhouse gases in the atmosphere. Greenhouse gases are gases capable of absorbing and emitting infrared radiation (heat). They absorb heat emitted from Earth and then re-emit it, causing some of the heat to be reflected back to the surface. If it weren't for greenhouse gases in the atmosphere, the Earth would be too cold to support liquid water. Therefore, greenhouse gases are vital for life on Earth. However, the excessive accumulation of greenhouse gases in the atmosphere leads to an increase in the Earth's average temperature and climate change. Today, the Earth's average surface temperature is approximately 1.2°C higher than it was before the Industrial Revolution.

Global climate change has numerous negative consequences for living organisms: extreme weather events, glacier melting, rising sea levels, etc. At the Climate Change Conference held in Paris in 2015, it was decided to take measures to limit global warming to 1.5°C to minimize all these adverse effects. However, recent scientific studies indicate that even a 1.5°C warming could have very negative consequences for the Earth.

Researchers propose two criteria for climate change. The first one is related to the concentration of carbon dioxide in the atmosphere. Human activities such as fossil fuel use cause the accumulation of carbon dioxide, a greenhouse gas, in the atmosphere. In the early Holocene, the concentration of carbon dioxide in the atmosphere was around 280 ppm (parts per million). Today, this value has risen to 417 ppm. According to researchers, a safe limit for atmospheric carbon dioxide concentration could be 350 ppm, which corresponds to a global warming target of 1.5°C, set at the Paris Climate Conference.

The second criterion is related to radiative forcing. The Earth receives energy from the Sun and also emits energy back into space. Changes in the Earth's energy balance caused by natural and anthropogenic factors contributing to climate change are referred to as radiative forcing. The most significant factors contributing to radiative forcing include greenhouse gases and aerosols released into the atmosphere, as well as changes in the Earth's reflectivity. Today, every square meter of the Earth's surface receives approximately 2.91 joules (J) more energy per second compared to pre-industrial levels. It is stated that this value should not exceed 1 J.

In conclusion, both carbon dioxide concentration and radiative forcing values currently exceed the threshold values.

Newly Developed Materials

Synthetic chemicals, nuclear waste, genetically modified organisms, and many other materials produced by human hands are being released into the environment. The effects of most of these materials on the global system are not well understood. There are numerous examples from the past where the harms of synthetically used materials were realized only later. For instance, the environmental damages caused by pesticides such as DDT or the effects of chlorofluorocarbons (CFCs), which were extensively used in various technologies in the past, on the ozone layer were recognized much later.

Ideally, materials whose effects on the global system are unknown should not be released into the environment. Therefore, the threshold value that should not be exceeded for the release of newly developed materials into nature should be "0".

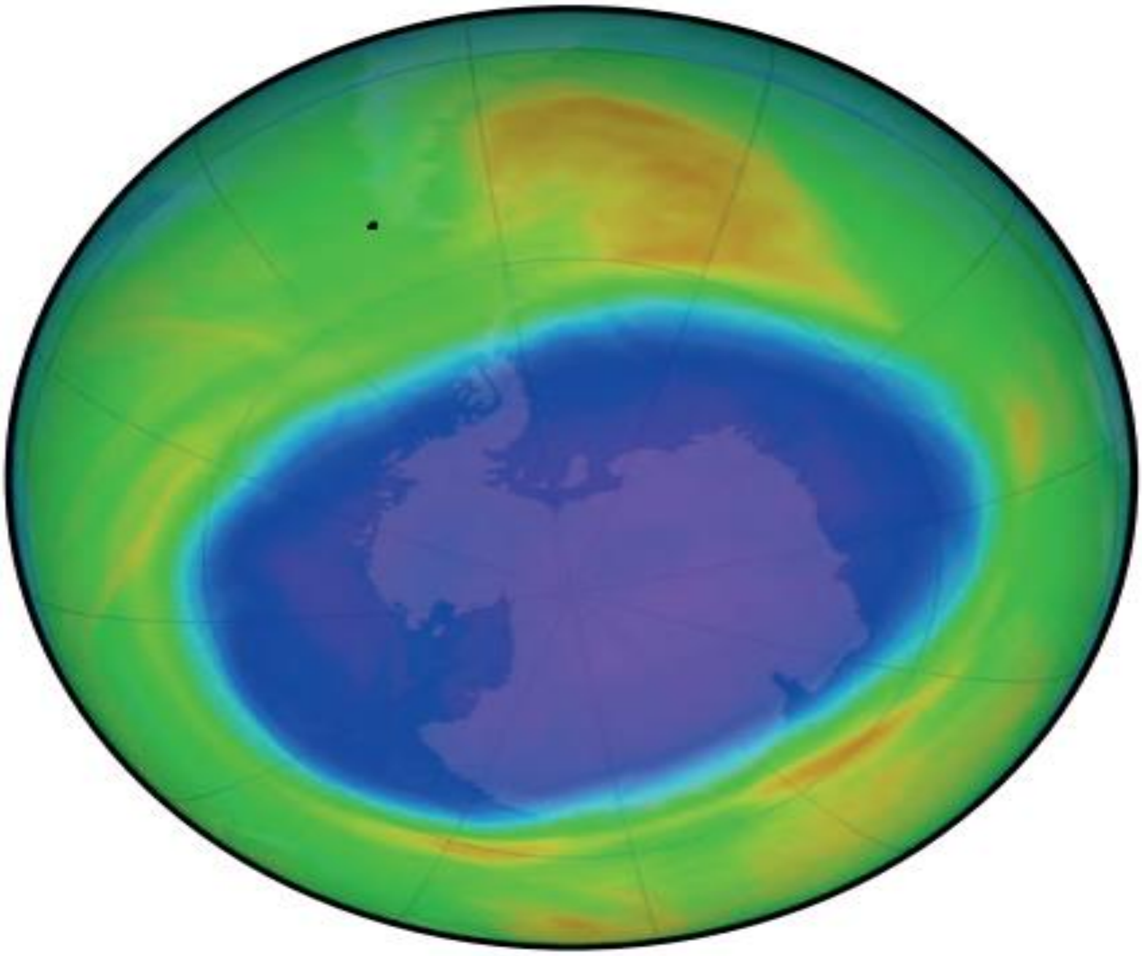
There is no data available on the amount of materials released into the environment worldwide without being tested for safety. However, it is known that more than 80% of chemicals registered under the European Union's Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) regulations have been in use for over a decade without undergoing any safety testing.

By looking at the REACH data, which only covers a small fraction of synthetic chemicals produced worldwide, one can get an idea of the magnitude of the problem.

Ozone Depletion

The ozone layer in the atmosphere protects the Earth's surface from harmful radiation coming from the Sun. In the 1980s, thinning of the ozone layer was detected over Antarctica. Scientific studies revealed that this thinning was caused by the release of chlorofluorocarbons (CFCs) and various other chemicals into the atmosphere. After restrictions were imposed on the production of ozone-depleting substances through the Montreal Protocol in 1987, the ozone layer began to recover.

To express the amount of ozone in the atmosphere, the Dobson unit (DU) is used, representing the amount of substance contained within an imaginary column rising from a point on the Earth's surface. Before the Industrial Revolution, the amount of ozone in the atmosphere was 290 DU. The threshold value that should not be exceeded (not fall below) for ozone quantity is considered to be 276 DU. Currently, the amount of ozone in the atmosphere is approximately 284 DU. Therefore, while the ozone quantity in the atmosphere is not as high as it was before the Industrial Revolution, it still falls within the safe range. Threshold values are now only exceeded during three-month periods when spring occurs in the Southern Hemisphere and only over areas located above Antarctica. It is expected that the recovery of the ozone layer will continue in the future.



Satellite image showing ozone depletion in Antarctica in 2020

Aerosols

Aerosols are solid particles or liquid droplets suspended in the atmosphere. Some sources of aerosols include desert dust, smoke from fires, and particles emitted during volcanic eruptions. It is challenging to make precise estimates of how much the aerosol quantity in the atmosphere has changed since the Industrial Revolution. However, based on various observational data, it is estimated that the amount of aerosols in the atmosphere has roughly doubled since the 1750s.

The Sahara Desert is currently the largest source of atmospheric dust. However, 5,000-15,000 years ago, this region was filled with lakes, wetlands, and vegetation.

To assess atmospheric aerosol loading, a metric called aerosol optical depth (AOD) is used. AOD represents the total amount of sunlight reaching the Earth's surface due to aerosols. In the past, observations of reduced rainfall associated with high AOD values in South Asia led to the establishment of a regional threshold value for South Asia. It was suggested that an AOD value exceeding 0.25 in monsoon regions could significantly reduce rainfall and disrupt biosphere integrity. Currently, the AOD value in South Asia is around 0.3, surpassing the threshold value.

Due to data limitations, it is unclear whether the same threshold value can be applied globally. The average AOD value for the entire Earth is currently around 0.14. Differences in AOD between the Northern and Southern Hemispheres, such as those observed in the West African and Indian monsoons, can also affect monsoon systems. Various factors, including natural and anthropogenic aerosols, contribute to significant temperature differences between the Northern and Southern Hemispheres.

Studies on aerosol-climate interactions following volcanic eruptions indicate that during periods of high AOD and large hemispheric disparities in AOD, the Northern Hemisphere receives less rainfall, whereas during periods of increased aerosol emissions in the Southern Hemisphere, the Northern Hemisphere receives more rainfall.

These findings are consistent with observations showing reduced average rainfall in tropical regions after major volcanic eruptions and are also consistent with global climate models.

In the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report, published in 2021, the decrease in monsoon rainfall between 1950 and 1980 was partly attributed to anthropogenic aerosol emissions in the Northern Hemisphere. The latest study suggests using the annual average AOD difference between hemispheres to measure aerosol loading.

The current annual average AOD difference between hemispheres is approximately 0.076. Due to seasonal increases in dust storms in the spring and summer in the Northern Hemisphere, this value can reach up to 0.1. Before the Industrial Revolution, it is estimated that the annual average difference was 0.03.

The threshold value that should not be exceeded for aerosol loading is set at 0.1. However, it is noted that further scientific research is needed to fully understand the effects of AOD differences, and the threshold value may need to be updated. Currently, the current value remains below the established threshold.

Ocean Acidification

One of the consequences of the increase in atmospheric carbon dioxide due to human activities is the acidification of ocean waters. When there is more carbon dioxide in the atmosphere, the amount of dissolved carbon dioxide in the waters naturally increases. This leads to an increase in the amount of dissolved carbonic acid in ocean waters, making them more acidic.

Corals, phytoplankton, and many other organisms living in the oceans use aragonite to form their shells and skeletons. The increased acidity of ocean waters means that aragonite, a form of calcium carbonate crystal, dissolves more easily. Therefore, the increasing acidity of ocean waters poses a threat to organisms that use aragonite in their shells and skeletons, as well as to other organisms that feed on them.

To define a planetary boundary for ocean acidity, the aragonite saturation state (Ω) of surface waters is used as a criterion. A Ω value of less than 1 means that aragonite will easily dissolve. Aragonite-dependent organisms live in waters where Ω values are above 1.

It is estimated that before the Industrial Revolution, the Ω value of surface waters of the oceans was approximately 3.44. The threshold value that should not be exceeded is considered to be 80% of this value. Currently, the Ω value of ocean surface waters is about 81% of what it was before the Industrial Revolution. Therefore, although the Ω value is within the safe range, it is very close to the threshold. If the atmospheric carbon dioxide concentration continues to increase in the future, a decrease in Ω values and exceeding the threshold is inevitable.

Deforestation

Forests play a crucial role in regulating the climate. However, total forested areas worldwide are decreasing due to reasons such as land clearing and wildfires. This planetary boundary focuses on forests in tropical and temperate regions, which play a significant role in the Earth's system, as well as northern forests near the North Pole.

The threshold values that should not be exceeded are determined by comparing current forested areas with the potential areas covered by forests in the early Holocene period. For tropical, temperate, and northern forests, these values are 85%, 50%, and 85% respectively.

When it comes to tropical forests, forest areas in North and South America have decreased to 83.9% of their pre-Industrial Revolution levels, forest areas in Africa to 54.3%, and forest areas in Asia to 37.5%. The values for temperate climate forests are as follows: 51.2% in North and South America, 34.2% in Europe, and 37.9% in Asia. The values for northern forests are: 56.6% in America and 70.3% in Eurasia. These values illustrate the extent of deforestation in the three main forested regions of the globe.

Looking at the total forested areas worldwide, the situation is similar. Currently, the total forested area on Earth has decreased to 60% of its pre-Industrial Revolution level. The threshold value for total forested areas is stated to be 75%.

Nitrogen and Phosphorus Pollution

Nitrogen and phosphorus are essential building blocks of life. Nowadays, fertilizers produced for agricultural use also contain nitrogen and phosphorus. While artificial fertilizers are beneficial for increasing agricultural production, they also harm the environment. Fertilizers dispersed into the environment due to human activities affect both the nitrogen and phosphorus cycles and cause pollution in soils and waters.

To prevent excessive oxygen depletion in oceans, it is stated that the annual phosphorus transported from freshwater to oceans should not exceed 11 million tons. However, the current amount of phosphorus transported from freshwater to oceans is approximately around 22.6 million tons. The upper limit for the amount of phosphorus mixed into erodible soils from fertilizers is determined to be 11.2 million tons annually. The current value is approximately 17.5 million tons. Therefore, both criteria have been exceeded.

As for nitrogenous fertilizers, the threshold that should not be exceeded is 62 million tons annually. There is a high level of uncertainty in the data regarding the nitrogenous fertilizers currently used. However, according to the Food and Agriculture Organization's data, the amount of nitrogen in human-produced fertilizers used in agriculture is around 190 million tons annually. This value significantly exceeds the threshold.

In Conclusion

Especially with the development of industry and the rapid increase in the world's population, human activities have caused significant damage to nature. The climate is changing rapidly, forest areas are decreasing, the rate of species extinction is alarmingly high, ocean acidity is increasing, access to freshwater sources is becoming more difficult, and synthetic chemicals are being released into the environment. All these changes signify a shift in the living conditions humans have been accustomed to for a long time. Scientific studies on planetary boundaries aim to determine the current level of these problems and to raise awareness among people about the steps that need to be taken for Earth to continue to sustain human communities as it has in the past.

The first study on planetary boundaries was published in 2009. Over the years, although the topics remained the same, the criteria and boundary values used in evaluations have been updated based on new findings. In a recent article, quantitative criteria were established for all planetary boundaries for the first time. The results indicate that boundaries have already been exceeded in terms of biosphere integrity, climate change, synthetic chemicals, nitrogen and phosphorus pollution, deforestation, and freshwater sources. While the boundaries for ocean acidity and atmospheric aerosols have not yet been crossed, the trends are heading in the wrong direction. The only headline where the boundary has not been exceeded and the trend is positive is ozone depletion.

Various efforts are being made today to address the problems caused by human activities. However, these efforts often focus on solving one problem at a time. Yet, many of these problems are interconnected. For example, climate change also affects biosphere integrity by increasing the rate of species extinction. Similarly, nitrogen and phosphorus pollution are another factor contributing to the extinction of species. Therefore, a holistic approach is needed to address the problems caused by human activities. A major underlying factor for many of these problems is the continuous expansion of human settlements. In the future, reducing carbon emissions, preventing deforestation, and adopting new agricultural practices will be necessary.

What Can Be Done to Prevent Climate Change?

1-Transition to Clean Energy: Transitioning from fossil fuels to clean energy sources (such as solar, wind, hydroelectric, geothermal) is one of the most effective ways to reduce carbon emissions. Encouraging renewable energy investments and supporting energy transformation are necessary steps.

2-Energy Efficiency: Increasing energy efficiency can reduce energy consumption and thus lower carbon emissions. Measures such as improving building insulation, using energy-efficient lighting and appliances can be implemented.

3-Sustainable Transportation: A significant portion of carbon emissions comes from the transportation sector. Sustainable transportation solutions include expanding public transportation networks, incentivizing electric vehicles, and creating bicycle lanes.

4-Conservation of Forests and Natural Areas: Protecting forests enhances carbon storage capacity and preserves biodiversity. Measures such as fire prevention, combating illegal logging, and supporting forest restoration projects are essential.

5-Sustainable Agriculture and Nutrition: Promoting sustainable farming practices can reduce the carbon footprint of agriculture. These include organic farming, water management, soil conservation, and reduced consumption of animal products.

6-Industrial Transformation and Green Technologies: Renewing industrial processes and production methods can reduce carbon emissions. Developing and adopting green technologies (such as renewable energy, energy storage, carbon capture and storage) are crucial.

7-Water Resource Management: Climate change can adversely affect water resources, so water management strategies are vital.

Measures such as water conservation, efficient water use, water purification, and recycling can be implemented.

8-Education and Awareness: Education and awareness-raising activities about climate change can motivate communities to take climate action. Educational institutions, media, and civil society organizations play a crucial role in this regard.

9-Policy and International Cooperation: Effective climate policies' formulation and implementation are critical in combating climate change. International cooperation and agreements facilitate global coordination and facilitate reaching common goals.

10-Social Transformation and Sustainable Development: Combating climate change should be integrated with social transformation and sustainable development efforts. Adopting just and inclusive policies, protecting disadvantaged groups, and reducing climate inequalities are essential.

These comprehensive measures require a multi-faceted and holistic approach to prevent climate change or minimize its impacts. Participation and collaboration from every sector and society are vital for effective climate action.

Climate Change and E-Coding Curriculum

Objective:

This curriculum is designed to help students understand climate change and develop e-coding skills to address it. It aims to empower students to utilize technology for combating climate change.

Target Audience:

Middle and high school students

Duration:

Total of 10 class hours (Each class hour is calculated as 45 minutes)

Content:

1-Introduction and Basic Concepts

- ❖ What is climate change and how does it occur?

- Effects of climate change on nature and humans.
- Understanding the causes and consequences of climate change.

2-Data Analysis and Visualization

- How climate data is collected and analyzed.
- Tools and techniques for data visualization.
- Interpreting climate change data.

3-Impact and Cause Analysis

- Analyzing the impacts of climate change in specific regions.
- Understanding and visualizing cause-effect relationships.

4-E-Coding Fundamentals

- Basic concepts of coding and its importance.
- Developing algorithmic thinking skills.
- Using block-based coding tools (e.g., Scratch, Blockly).

5-Technology in Climate Change Mitigation

- Role of technology in combating climate change.
- Renewable energy sources and technologies (solar energy, wind energy, etc.).
- Sustainability technologies and applications.

6-Project: Generating Solutions for Climate Change

- Students will develop a project addressing climate change mitigation.
- The project should incorporate technology usage and e-coding skills.
- Example project ideas: developing environmental monitoring devices, creating applications to enhance energy efficiency, designing sustainable agricultural technologies.

7-Presentation and Feedback

- Students will present their projects to the class and receive feedback.

- Feedback should cover technical aspects of the project and propose solutions related to climate change.

8-Community Engagement

- Students will participate in community activities related to climate change.
- Activities may include environmental clean-up, tree planting events, attending climate change conferences.

9-Sustainability and Continuity

- Students will contemplate the sustainability and continuity of their projects.
- Ideas for further development and expansion of projects will be discussed.

10-Assessment and Next Steps

- Students will evaluate their progress and the knowledge and skills acquired during the curriculum.

- A plan for future steps and continued learning will be formulated.

Resources and Tools:

- NASA Climate Kids: Interactive resources and games about climate change.
- Block-based coding platforms like Scratch or Blockly.
- Introductory courses for text-based programming languages like Python or JavaScript.
- Online databases and tools for climate change data analysis.

This curriculum provides a comprehensive framework for students to understand climate change and develop e-coding skills to address it. It encourages students to utilize information technologies to devise solutions for sustainability.

Effects of Climate Change on Forests

1-Increased Temperature and Drought:

- High temperatures and reduced rainfall create drought stress in forest ecosystems.
- Drought can result in withering of vegetation and water stress in trees, negatively impacting forest health.

2-Increased Forest Fires:

- High temperatures and drought increase the frequency and intensity of forest fires.
- Forest fires lead to the burning of vegetation and the loss of habitats, resulting in reduced biodiversity.

3-Habitat Loss and Biodiversity Decline:

- Climate change alters or destroys the habitats of certain plant and animal species.
- Deforestation or habitat alteration leads to loss of habitat and decline in biodiversity.

4-Spread of Pests and Diseases:

- High temperatures and humidity encourage the spread of pests and diseases in forest ecosystems.
- This affects the health and resilience of trees, altering the forest structure.

5-Soil Erosion and Plant Nutrition:

- Excessive rainfall or severe storms increase soil erosion, reducing soil fertility.
- Soil erosion affects plant nutrition and can severely impact forest health.

6-Changes in Biogeochemical Cycles:

- Climate change affects the cycles of carbon, nitrogen, and other important elements.
- These changes have profound effects on soil fertility, plant nutrition, and ecosystem functions.

7-Decrease in Water Resources:

- Increased temperatures and drought can decrease water resources in forests.
- This results in vegetation drying out and disruption of the water balance in forest ecosystems.

8-Carbon Emissions and Carbon Storage Capacity:

- Deforestation or damage to forests reduces carbon storage capacity and may lead to increased carbon emissions.
- This accelerates climate change, creating a vicious cycle.

The impacts of climate change on forests are complex and result from a combination of factors. Protecting forest ecosystems and ensuring sustainable management are crucial for mitigating these adverse effects.

E-Coding Curriculum: Effects of Climate Change on Forests

Module 1: Basics of Climate Change and Forest Ecosystems

Lesson 1: What is Climate Change? (45 minutes)

- An interactive presentation on the concept of climate change and its causes.
- Discussion on the reasons and impacts of climate change.

Lesson 2: Forest Ecosystems and Their Climate Regulatory Role (45 minutes)

- An interactive simulation using Scratch or similar block-based programming to explore the components and functions of forest ecosystems.
- Group work among students to discuss the climate regulatory role of forests and present their findings.

Module 2: Impacts of Climate Change on Forests

Lesson 3: Rising Temperatures and Drought (45 minutes)

- A practical exercise using a Python program to simulate the impacts of rising temperatures and drought on forests.

- Students are tasked with creating graphs illustrating how forest ecosystems change under specified conditions.

Lesson 4: Forest Fires and Habitat Loss (45 minutes)

- A coding project investigating the causes and consequences of forest fires.
- Students develop a game using Scratch or a similar platform to simulate habitat loss and its effects on biodiversity.

Module 3: Conservation and Sustainable Management of Forests

Lesson 5: Conservation and Restoration of Forests (45 minutes)

- A coding activity emphasizing the importance of conserving and restoring forests.
- Students are required to create an interactive webpage showcasing forest restoration projects.

Lesson 6: Sustainable Forest Management (45 minutes)

- A project focusing on the principles of sustainable forest management.

- Students develop a project using Scratch or a similar platform to simulate sustainable forest management practices.

Module 4: Combating Climate Change in Forests

Lesson 7: Forests and Climate Change Mitigation (45 minutes)

- A coding activity explaining the role of forests in mitigating climate change.
- Students develop a project using Python or a similar language to simulate forest-based carbon emission reduction strategies.

Project Presentations and Discussion (45 minutes)

- Students prepare presentations on a project covering the learned topics.
- Followed by an in-class discussion and feedback exchange.

This curriculum aims to equip students with both theoretical knowledge and practical coding skills to understand the effects of climate change on forests. Coding tools are utilized to facilitate deeper exploration and learning by students.

Climate Change to Waters Effects

1-Changes in Precipitation Patterns:

- Climate change alters global atmospheric circulation patterns, leading to shifts in precipitation regimes. Some regions may experience increased rainfall intensity and frequency, resulting in more frequent and severe flooding events. Conversely, other regions may face prolonged droughts and water scarcity due to reduced precipitation.
- These changes in precipitation patterns can have profound effects on ecosystems, agriculture, water supply, and infrastructure. They may also increase the risk of landslides, soil erosion, and waterborne diseases.

2-Melting Glaciers and Ice Caps:

- Rising temperatures accelerate the melting of glaciers and ice caps, contributing to rising sea levels. This phenomenon has immediate and long-term consequences for coastal communities, as it increases the risk of inundation, coastal erosion, and saltwater intrusion into freshwater sources.
- Furthermore, the loss of glacial ice reduces the availability of freshwater resources downstream, impacting ecosystems, agriculture, and communities that depend on glacial meltwater for irrigation and drinking water.

3-Sea Level Rise:

- Sea level rise is primarily driven by the thermal expansion of seawater due to warming temperatures and the melting of polar ice caps and glaciers. As sea levels rise, coastal habitats, infrastructure, and communities become increasingly vulnerable to inundation, erosion, and storm surges.
- Coastal ecosystems, such as wetlands and mangroves, face the risk of habitat loss and degradation, which can have cascading effects on biodiversity, fisheries, and coastal protection.

4-Changes in Hydrological Cycles:

- Climate change disrupts the natural hydrological cycle by altering precipitation patterns, evaporation rates, and runoff dynamics. Changes in the timing and distribution of rainfall affect the availability and distribution of surface water and groundwater resources.
- Shifts in hydrological cycles can lead to water stress, particularly in regions already experiencing water scarcity. This, in turn, exacerbates competition for limited water resources and can trigger conflicts over water allocation and management.

5-Water Quality Degradation:

- Climate change influences water quality through various mechanisms, including changes in temperature, precipitation patterns, and land use practices. Increased temperatures can elevate water temperatures, leading to reduced oxygen levels and the proliferation of harmful algal blooms.
- Changes in precipitation patterns can exacerbate nutrient runoff from agricultural areas, leading to eutrophication, algal blooms, and contamination of water bodies. Extreme weather events, such as heavy rainfall and flooding, can also mobilize pollutants and sediment, degrading water quality.

6-Shifts in Ecosystems:

- Changes in water availability and quality alter aquatic ecosystems, affecting species composition, distribution, and ecological interactions. For example, altered river flows can disrupt fish migration patterns and spawning habitats, leading to declines in fish populations.
- Coastal ecosystems, such as coral reefs and estuaries, are particularly vulnerable to climate change-induced stressors, including ocean acidification, sea level rise, and extreme weather events. These impacts can result in biodiversity loss, habitat degradation, and ecosystem collapse.

7-Impacts on Agriculture and Food Security:

- Changes in water availability and variability directly affect agricultural productivity and food security. Droughts, floods, and water scarcity can reduce crop yields, damage infrastructure, and disrupt supply chains, leading to food shortages and price volatility.
- Smallholder farmers, particularly those in developing countries, are disproportionately affected by climate change-induced water stress, as they often lack access to irrigation, water storage, and resilient crop varieties.

8-Water Scarcity and Conflict:

- Climate change exacerbates water scarcity in regions already facing water stress, increasing competition for limited water resources. This competition can lead to conflicts between competing users, such as agriculture, industry, and municipalities, as well as between upstream and downstream stakeholders.
- Water scarcity and associated conflicts have socio-economic and geopolitical implications, contributing to displacement, migration, social unrest, and interstate tensions.

Addressing these multifaceted challenges requires integrated and adaptive water management strategies that promote resilience, sustainability, and equity. This includes investments in water infrastructure, watershed management, climate-resilient agriculture, ecosystem restoration, and community engagement. Moreover, international cooperation and policy frameworks are essential to address transboundary water issues and promote equitable access to water resources in a changing climate.

What can be done to reduce the impact of climate change on waters?

Preventing the adverse effects of climate change on water resources requires a multi-faceted approach that addresses both mitigation (reducing greenhouse gas emissions) and adaptation (building resilience to climate impacts). Here are some key strategies:

1-Reducing Greenhouse Gas Emissions:

- Transitioning to renewable energy sources such as solar, wind, and hydroelectric power to reduce reliance on fossil fuels and lower carbon emissions.
- Implementing energy efficiency measures in industries, transportation, and buildings to reduce energy consumption and greenhouse gas emissions.
- Promoting sustainable land use practices, such as reforestation, afforestation, and reducing deforestation, to enhance carbon sequestration and mitigate emissions.

2-Enhancing Water Efficiency and Conservation:

- Implementing water-saving technologies and practices in agriculture, industry, and households to reduce water consumption and minimize waste.
- Investing in water-efficient irrigation systems, drip irrigation, and rainwater harvesting to optimize water use in agriculture and improve crop yields.
- Promoting public awareness and education on the importance of water conservation and responsible water management practices.

3-Protecting and Restoring Ecosystems:

- Preserving and restoring natural ecosystems, such as wetlands, forests, and mangroves, that provide critical ecosystem services, including water purification, flood control, and habitat preservation.
- Implementing green infrastructure projects, such as vegetated buffers, permeable surfaces, and green roofs, to enhance natural water retention and filtration processes in urban areas.
- Establishing protected areas and conservation zones to safeguard biodiversity and ecosystem resilience in the face of climate change.

4-Improving Water Governance and Management:

- Strengthening integrated water resource management (IWRM) frameworks to enhance coordination and collaboration among government agencies, stakeholders, and communities in water planning and decision-making.
- Developing and enforcing water allocation and use regulations that promote equitable access to water resources, prioritize ecosystem needs, and ensure sustainable water management practices.
- Investing in water infrastructure and storage facilities, such as dams, reservoirs, and water distribution systems, to

enhance water supply reliability and resilience to climate variability.

5-Building Climate Resilience:

- Conducting vulnerability assessments and risk mapping to identify areas and communities most vulnerable to climate change impacts, such as floods, droughts, and sea-level rise.
- Developing and implementing climate adaptation strategies and action plans that integrate climate considerations into water management, land-use planning, infrastructure development, and disaster risk reduction efforts.
- Investing in early warning systems, climate-resilient infrastructure, and emergency preparedness measures to enhance resilience to extreme weather events and natural disasters.

6-Fostering International Cooperation:

- Strengthening international cooperation and collaboration on water management, climate change adaptation, and disaster risk reduction through regional partnerships, multilateral agreements, and knowledge-sharing platforms.
- Supporting developing countries in building capacity, mobilizing finance, and accessing technology transfer to

enhance their resilience to climate change impacts and achieve sustainable water management goals.

- Incorporating water-related issues into global climate negotiations and agreements, such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, to ensure coordinated action on water and climate change at the international level.

By implementing these strategies, we can mitigate the adverse effects of climate change on water resources, build resilience to climate impacts, and ensure sustainable water management for current and future generations.

E-Coding Curriculum: Effects of Climate Change on Water

Week 1: Climate Change and Water Resources

Objective:

Understanding the effects of climate change on water resources.

Activities:

Lesson 1: What is Climate Change? (45 minutes)

-Introduce the concept of climate change and explain how it occurs.

-Discuss the effects of climate change on the water cycle.

Lesson 2: Water Resources and the Water Cycle (45 minutes)

-Learn about the types of water resources and the functioning of the water cycle.

-Emphasize the effects of climate change on water resources.

Week 2: Temperature Rise and Drought

Objective:

Understanding the effects of increased temperature and drought on water resources.

Activities:

Lesson 3: Increased Temperature and Water Resources (45 minutes)

-Examine the effects of increased temperature on water resources.

-Discuss the effects of temperature rise on water evaporation and vapor density.

Lesson 4: Drought and Water Scarcity (45 minutes)

-Address the effects of drought and water scarcity on water resources.

-Discuss water management and conservation strategies during drought periods.

Week 3: Floods and Flooding

Objective:

Increasing awareness about the risk of floods and flooding due to climate change.

Activities:

Lesson 5: Flood Events and Risk of Flooding (45 minutes)

-Analyze the effects of climate change on flood events and the risk of flooding.

-Discuss measures to cope with floods and flooding.

Lesson 6: Flash Floods and Infrastructure Damage (45 minutes)

-Evaluate the effects of flash floods on infrastructure and living standards.

-Research climate-resilient infrastructure and water management strategies.

Week 4: Sea Level Rise and Coastal Erosion

Objective:

Understanding the effects of sea level rise and coastal erosion.

Activities:

Lesson 7: Sea Level Rise and Coastal Erosion (45 minutes)

-Learn about the effects of climate change on sea level rise and coastal erosion.

-Discuss protection and adaptation strategies for coastal infrastructure and ecosystems.

Lesson 8: Coastal Erosion and Coastal Protection Projects (45 minutes)

-Examine the causes and effects of coastal erosion.

-Investigate the effectiveness of coastal protection and restoration projects.

Week 5: Water Quality and Ecosystems

Objective:

Understanding the effects of climate change on water quality and ecosystems.

Activities:

Lesson 9: Water Quality and Pollution (45 minutes)

-Discuss the effects of climate change on water quality.

-Evaluate the effects of pollution on water resources and ecosystems.

Lesson 10: Ecosystems and Water Resources (45 minutes)

-Learn about the effects of climate change on aquatic ecosystems and water resources.

-Study ecosystem-based water management and conservation strategies.

Week 6: Adaptation and Sustainable Water Management

Objective:

Promoting sustainable water management practices and adaptation strategies.

Activities:

Lesson 11: Adaptation to Climate Change (45 minutes)

- Discuss strategies for adapting to the effects of climate change on water resources.
- Explore examples of adaptation policies and practices.

Lesson 12: Sustainable Water Management (45 minutes)

-Learn about the principles of sustainable water resources management.

-Develop strategies and solutions for sustainable water use.

-Project Presentations and Evaluation

-Students will prepare and present a project on the topics they have learned.

-Project presentations and subsequent discussions will include assessments of student participation and the learning process.

This curriculum aims to provide students with fundamental knowledge and skills to understand the effects of climate change on water and cope with these effects. The activities will enable students to gain a deeper understanding of the topic and develop problem-solving skills using e-coding tools.