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Air Quality Index (AQI)

Topics Covered

What is the news?

- Because of the severe levels of pollution in Delhi and Mumbai, the Air Quality Index (AQI) has recently been in the news.
- In recent weeks, Delhi and Mumbai have consistently recorded AQI scores in the extremely poor and severe categories. This is due to a variety of reasons such as vehicular emissions, industrial pollution, stubble burning, and building site dust.
- The high levels of air pollution in Delhi and Mumbai pose a major health risk to their populations. Air pollution has been linked to a variety of health issues, including respiratory infections, heart disease, and cancer. It is particularly dangerous to children, pregnant women, and the elderly.

The Air Quality Index is a measure of air

pollution and its health consequences:

Introduction:

- Air pollution is one of the most serious environmental issues confronting the planet today. It has an impact on the quality of life, health, and well-being of millions of people, particularly in cities. Climate change, acid rain, ozone depletion, and biodiversity loss can all be exacerbated by air pollution. As a result, monitoring and controlling the quantities of air contaminants in the environment is critical.

Using an Air Quality Index (AQI) is one method of doing so.

- An AQI is a metric designed by government agencies to communicate to the public how dirty the air is now or will become in the future. As levels of air pollution grow, so does the AQI, as does the accompanying public health risk4.

How does the AQI function?

- The methods and criteria used to calculate and report AQI vary by country. However, the main premise is to measure the concentrations of the most prevalent air pollutants, such as particulate matter (PM), ozone (O3), nitrogen dioxide (NO2), sulphur dioxide (SO2), and carbon monoxide (CO), in the ambient air. These contaminants are proven to be harmful to both human health and the environment.

The AQI is classified into six groups:

AQI	Associated Health Impacts
Good (0–50)	Minimal Impact
Satisfactory (51–100)	May cause minor breathing discomfort to sensitive people.
Moderately polluted (101–200)	May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults.
Poor (201–300)	May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease
Very Poor (301–400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.
Severe (401-500)	May cause respiratory impact even on healthy people, and serious health impacts on people with lung/heart disease. The health impacts may be experienced even during light physical activity.

- **Good (0-50):** Air quality is deemed satisfactory, and air pollution poses little or no health risk.
- **Satisfactory (51-100):** Air quality is tolerable, but persons who are sensitive to air pollution may face a modest risk to their health.
- **Moderate (101-200):** Air quality is deemed unhealthy for vulnerable groups such as children, the elderly, and persons suffering from heart or lung illness.
- **Poor (201-300):** The air quality is hazardous to everyone. Everyone may suffer health consequences, and members of vulnerable groups may suffer more severe consequences.
- **Very Poor (301-400):** The air quality is dangerous, and anyone could get sick. Members of vulnerable groups may encounter severe health difficulties.
- **Severe (401-500):** The air quality is extremely

hazardous, and everyone may suffer major health consequences.

The AQI is a color-coded measure that helps people understand the present state of air quality and related health risks. The AQI's six colours are as follows:

AQI Category, Pollutants and Health Breakpoints								
AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5 – 1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

**One hourly monitoring (for mathematical calculations only)*

The National Air Quality Index (NAQI) monitors and reports the following eight pollutants:

- **Particulate Matter (PM):** Particulate Matter (PM) is a term used to describe tiny solid or liquid particles in the air that vary in size, shape, and content. They are

produced by a variety of sources, including cars, factories, biomass burning, construction, and road dust. They can also be generated in the atmosphere as a result of chemical interactions between other contaminants. The diameter of the particles divides PM into two categories: PM10 (particles with a diameter of 10 micrometres or less) and PM2.5 (particles with a diameter of 2.5 micrometres or less). PM can lead to a variety of health issues, including respiratory infections, asthma, bronchitis, lung cancer, and cardiovascular disease. PM can also limit visibility and cause crop loss and monument damage.

- **Nitrogen Dioxide (NO2)** is a reddish-brown gas that has a strong odour. It is mostly produced by the combustion of fossil fuels, such as those used in automobiles, power plants, and factories. It can also be released as a byproduct of agricultural activities such as fertiliser use and livestock dung. NO2 can combine with other pollutants to generate ozone, acid rain, and secondary particulate matter. NO2 can irritate the eyes, nose, and throat, as well as aggravate respiratory disorders including asthma and bronchitis. NO2 can also impair the immune system and increase the likelihood of infection.
- **Sulphur Dioxide (SO2)** is a colourless gas that has a stifling odour. It is mostly created by the combustion of coal and oil in power plants, industry, and vehicles. Volcanoes, geothermal operations, and biomass burning can all emit it. Acid rain, secondary PM, and sulphates can develop when SO2 reacts with other pollutants. SO2 can irritate the eyes, nose, and throat, as well as aggravate respiratory disorders such as asthma and bronchitis. SO2 can also harm plants, soil, and aquatic life.
- **Ozone (O3)** is a colourless gas with a strong odour. It is generated in the atmosphere by the interaction of NO2 with volatile organic compounds (VOCs) in the presence of sunlight, rather than being emitted directly from any

source. VOCs are organic compounds that quickly evaporate, such as those found in paints, solvents, fuels, and perfumes. O3 is advantageous in the high atmosphere because it shields the earth from harmful ultraviolet rays. However, O3 is toxic in the lower atmosphere, where it functions as a pollutant. O3 can induce lung irritation, coughing, wheezing, and shortness of breath. O3 can also harm crops, plants, and building materials.

- **Carbon monoxide (CO)** is a gas that is colourless, odourless, and tasteless. It is mostly formed by the incomplete combustion of carbon-containing fuels, such as those used in vehicles, businesses, and homes. It is also produced by forest fires and tobacco smoke. CO can diminish the oxygen-carrying capacity of the blood and affect the heart, brain, and nervous system's function. At high concentrations, CO can cause headaches, dizziness, nausea, exhaustion, and even death. CO can also contribute to ozone and greenhouse gas creation.
- **Ammonia (NH3)** is a colourless gas with a strong odour. It is mostly produced by agricultural activities such as fertiliser application, manure management, and livestock waste. It can also be produced by industrial activities like chemical manufacture and refrigeration. Ammonium salts, which are a component of PM, can be formed when NH3 reacts with other contaminants. NH3 can irritate the eyes, nose, and throat, as well as aggravate respiratory disorders such as asthma and bronchitis. NH3 can also have an impact on soil acidity and nutrient balance, as well as disrupt aquatic life.
- **Lead (Pb)** is a heavy metal that can exist in a variety of forms, including dust, vapours, and particles. It is primarily produced by the combustion of leaded petrol, the smelting of lead ores, and the manufacture of batteries. It can also be emitted by lead-containing paints, cosmetics, and toys. Pb can build up in the body and have an impact on the neurological system, brain,

kidneys, liver, and bones. Pb has been linked to learning difficulties, behavioural issues, anaemia, and hypertension. Pb has the potential to pollute the food chain and the environment.

What's the distinction between PM2.5 and PM10?

- The size of the particles differs between PM2.5 and PM10. Particulate matter (PM) refers to microscopic solid or liquid particles in the air that can be hazardous to health and the environment. The figures 2.5 and 10 represent the particle diameter in micrometres (or microns), which are one-millionth of a metre. A human hair is approximately 70 microns thick1.
- PM2.5 are minuscule inhalable particles with diameters of 2.5 microns or less. They can enter the bloodstream and penetrate deep into the lungs, producing a variety of respiratory and cardiovascular disorders such as asthma, bronchitis, heart attack, and stroke. PM2.5 can also have an impact on the brain, neurological system, and reproductive system. PM2.5 emissions can occur from a variety of sources, including vehicle exhaust, power plants, industrial activities, biomass burning, and wildfires24.
- PM10 particles are inhalable particles with a diameter of 10 microns or less. They have the ability to reach the throat and upper lungs, causing discomfort, coughing, sneezing, and allergic reactions. PM10 can potentially exacerbate pre-existing lung disorders such chronic obstructive pulmonary disease (COPD). Road dust, construction operations, agriculture, and

sea salt are all sources of PM10.

The World Health Organisation (WHO), the United States Environmental Protection Agency (EPA), and the Central Pollution Control Board (CPCB) of India all monitor and control PM2.5 and PM10. Based on scientific knowledge of the health effects of these pollutants, they have created various standards and guidelines for permissible levels of these pollutants in the ambient air. For example, the WHO advises that annual average PM2.5 concentrations not exceed 10 micrograms per cubic metre (g/m3) and yearly average PM10 concentrations not exceed 20 g/m32. However, many countries and regions have PM2.5 and PM10 levels that exceed WHO standards, posing major health concerns to their populations. As a result, it is critical to take steps to limit pollution emissions and exposure, such as adopting clean energy sources, upgrading public transportation, implementing emission standards, and wearing masks.

What is the significance of the AQI?

- The AQI is significant because it allows us to assess the quality of the air we breathe as well as the potential health hazards linked with air pollution. It also allows us to monitor changes in air quality over time and assess the efficacy of air pollution management efforts.
- The AQI also provides public health advice and suggestions to protect themselves from the negative impacts of air pollution. People with respiratory or cardiovascular problems, children,

the elderly, and pregnant women, for example, are more vulnerable to air pollution and should avoid outdoor activities when the AQI is high. People should also minimise their air pollution emissions by taking public transit, carpooling, or biking instead of driving, as well as conserving energy at home and at work.

Infection and Air Quality Relation:

- According to research, there is a link between air pollution and infection. People who reside in polluted environments are more prone to become infected with COVID-19 and experience more severe symptoms.
- This is due to the fact that air pollution can harm the lungs and make them more prone to illness. Air pollution can also impair the immune system, making it more difficult for the body to fight infection.

The Future of AQI:

- The issue of air pollution will not go away on its own. We must take measures to limit air pollution and safeguard our health.
- This can be accomplished by the government investing in renewable energy, supporting public

transit, and cracking down on industrial polluters. Individuals can help by lowering their own carbon footprint and supporting legislation that promote clean energy.

AQI in India:

- In terms of poor air quality, some cities in India are among the most polluted in the world. According to the World Health Organisation (WHO), air pollution kills approximately 1.67 million people in India each year. Vehicle emissions, industrial emissions, biomass burning, construction activities, road dust, and agricultural residue burning are some of the major contributors of air pollution in India.
- To address this issue, India launched the National

Air Quality Index (NAQI) in 2015, based on the AQI concept used in the United States. The NAQI measures the following pollutants: PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb. The NAQI is classified into six levels: Good (0-50), Satisfactory (51-100), Moderately Polluted (101-200), Poor (201-300), Very Poor (301-400), and Severe (401-500).

- The NAQI is reported by the Central Pollution Control Board (CPCB) and the State Pollution Control Boards (SPCBs) across the country using a network of air quality monitoring stations. NAQI data is also made available to the public via a variety of venues, including websites, mobile apps, social media, newspapers, and electronic display boards. The NAQI's goal is to increase awareness and encourage individuals to take action to minimise air pollution and its negative health effects.

Why air pollution increases in Delhi during the winter months?

There are a number of reasons why air pollution increases in Delhi during the winter months.

- Air pollution increases in winter in Delhi due to a combination of geographical and meteorological factors. Delhi is located in a landlocked region, surrounded by the Himalayas in the north and the Aravalli hills in the south. This limits the dispersion of pollutants from the city and traps them in a layer of cold air near the

ground. The cold air is denser and more stable than the warm air above it, creating a phenomenon called temperature inversion. Temperature inversion prevents the vertical mixing of air and pollutants, and leads to the formation of a thick smog over the city. The smog is further aggravated by the low wind speed and high humidity in winter, which reduce the dilution and removal of pollutants.

- ***Inversion:*** An inversion layer is a layer of warm air that traps pollutants close to the ground. Inversions are more common in the winter months because the air is colder and denser.

    - An inversion is a layer of air in the atmosphere where the temperature increases with altitude. This is the opposite of the normal temperature profile, where the temperature decreases with altitude. Inversions can occur at any altitude in the atmosphere, but they are most common in the lower troposphere (the lowest level of the atmosphere).

There are two main types of inversions:

- **Surface inversions:** These inversions occur at the ground surface. They are caused by cooling of the ground at night, which cools the air above it. Surface inversions are most common in the winter months, when the ground can cool significantly overnight.

- **Upper-level inversions:** These inversions occur higher up in the atmosphere. They are caused by subsidence, which is the downward movement of air. Subsidence can be caused by a variety of factors, such as high pressure systems and mountain ranges.

Inversions can have a significant impact on air quality. When an inversion is present, it can trap pollutants near the ground, making it difficult for them to disperse. This can lead to high levels of air pollution, especially in urban areas.

- ***Stubble burning:*** Farmers in Punjab and Haryana often burn crop stubble after the harvest. This releases large amounts of pollutants into the air, which can travel to Delhi and other nearby cities.
- ***Reduced wind speed:*** Wind speed tends to be lower in the winter months, which means that pollutants do not disperse as easily.
- ***Increased vehicular emissions:*** More people tend to use their cars in the winter months, which can lead to increased emissions.
- ***Industrial emissions:*** Some industries, such as power plants and cement factories, emit pollutants into the air. These emissions can be worse in the winter months if the industries are not equipped with proper pollution control measures.

Why does air pollution grow in winter in Mumbai, despite the fact that it is surrounded by water, as opposed to Delhi, which is landlocked?

While Mumbai’s coastal location provides some advantages in terms of air quality, it is important to note that the sea breeze, which typically helps disperse pollutants, can be weakened during the winter months. This, along with other factors, contributes to increased air pollution in Mumbai during this time. Here are some specific reasons why air pollution increases in Mumbai during the winter even with its coastal location:

- **Meteorological Conditions:** During the winter months, Mumbai experiences a decrease in wind speed and an increase in atmospheric stability. This stagnant air traps pollutants closer to the ground, preventing them from dispersing effectively. This phenomenon is more pronounced in Mumbai compared to Delhi due to its coastal location, as the sea breeze typically helps to disperse pollutants. However, during the winter months, the sea breeze weakens, allowing pollutants to accumulate.
- **Vehicular Emissions:** Mumbai is a densely populated city with a large number of vehicles on the road, and the combustion of fuel releases a variety of pollutants, including particulate matter (PM), nitrogen oxides (NOx), and sulfur dioxide (SO2). These emissions contribute significantly to air pollution, especially during the winter months when the sea breeze is weaker.
- **Industrial Emissions:** Mumbai is home to a number of industries, including power plants, refineries, and chemical factories, which release a variety of pollutants into the air, including PM, NOx, SO2, and volatile organic compounds (VOCs). These emissions exacerbate the air pollution problem, particularly during the winter when atmospheric

conditions are unfavorable.

- **Resuspension of Dust:** During the dry winter months, dust from construction sites, unpaved roads, and open fields can be easily resuspended into the air by even light winds. This resuspended dust can significantly increase PM levels, further deteriorating air quality.
- **Crop Stubble Burning:** Although Mumbai itself is not an agricultural area, the smoke from crop stubble burning in neighboring states, particularly Punjab and Haryana, can travel long distances and contribute to the city's air pollution. This issue is particularly prominent during the winter months when wind patterns favor the transport of smoke from these regions.
- **Lack of Green Cover:** Mumbai has a relatively low green cover compared to other major cities in India. Trees and plants play a crucial role in removing pollutants from the air, and their absence further exacerbates the air pollution problem. Increasing green cover could help to mitigate air pollution, but this requires concerted efforts from the government and citizens.
- **Improper Waste Management:** Improper waste disposal, including burning of garbage, releases harmful pollutants into the air, further aggravating the air quality. Implementing effective waste management practices, including segregation, collection, and treatment of waste, could help reduce this source of pollution.
- **Domestic Emissions:** Cooking and heating with traditional fuels, such as wood and kerosene, in households contribute to indoor air pollution, which can spill over into outdoor air quality. Promoting the use of cleaner fuels and improving ventilation in homes could help reduce these

emissions.

In conclusion, while Mumbai’s coastal location provides some advantages in terms of air quality, the city is not immune to air pollution, especially during the winter months when meteorological conditions are unfavorable and other factors contribute to increased emissions. Addressing air pollution requires a multi-pronged approach that includes reducing vehicular emissions, controlling industrial emissions, improving waste management, promoting cleaner fuels, and increasing green cover.

QuizTime:

Which of the following is a particulate matter smaller than 2.5 micrometers?

(a) PM2.5
(b) PM10
(c) Ozone
(d) Nitrogen dioxide
(e) Sulfur dioxide

- Answer: (a) PM2.5
- Explanation: PM2.5 is particulate matter with a diameter of 2.5 micrometers or less. It is the smallest type of particulate matter and the most harmful to human health.

Which of the following is a major source of both PM2.5 and PM10?

(a) Vehicle emissions
(b) Industrial emissions
(c) Power plants
(d) Biomass burning
(e) All of the above

- Answer: (e) All of the above
- Explanation: Vehicle emissions, industrial emissions, power plants, and biomass burning are all major sources of both PM2.5 and PM10. These sources emit a variety of pollutants into the air, including particulate matter, which can then be inhaled by people.

Exposure to PM2.5 and PM10 can increase the risk of which of the following diseases?

(a) Respiratory infections
(b) Heart disease
(c) Cancer
(d) All of the above

- Answer: (d) All of the above
- Explanation: Exposure to PM2.5 and PM10 can increase the risk of a variety of diseases, including respiratory infections, heart disease,

and cancer. It is important to reduce your exposure to PM2.5 and PM10 to protect your health.

Mains Questions:

Discuss the sources and health impacts of PM2.5 and PM10. What steps can be taken to reduce exposure to these pollutants?

Model Answer:

Sources of PM2.5 and PM10

PM2.5 and PM10 can come from a variety of sources, including:

- Vehicle emissions
- Industrial emissions
- Power plants
- Biomass burning (e.g., crop stubble, wood, and trash)
- Natural sources (e.g., dust storms, wildfires)
- Health impacts of PM2.5 and PM10

Exposure to PM2.5 and PM10 can have a number of negative health impacts, including:

- Respiratory infections (e.g., asthma, bronchitis, pneumonia)
- Heart disease
- Cancer
- Stroke
- Lung damage
- Skin problems
- Eye problems
- Reproductive problems
- Neurological problems

Steps to reduce exposure to PM2.5 and PM10

There are a number of things that can be done to reduce exposure to PM2.5 and PM10, including:

- Avoid spending time outdoors when air quality levels are high.
- Wear a mask when you are outdoors in polluted areas.
- Keep your windows and doors closed when air quality levels are high.
- Use an air purifier in your home.
- Reduce your reliance on cars and use public transportation, walk, or bike whenever possible.
- Support policies that promote clean energy and reduce industrial emissions.

What role can the government play in reducing air pollution and protecting public health from the

harmful effects of PM2.5 and PM10?

Model Answer:

The government can play a significant role in reducing air pollution and protecting public health from the harmful effects of PM2.5 and PM10. Some of the steps that the government can take include:

- Investing in clean energy and renewable energy sources, such as solar and wind power.
- Promoting public transportation and making it more accessible and affordable.
- Implementing stricter emissions standards for vehicles and industrial facilities.
- Providing subsidies for electric vehicles and other clean transportation options.
- Planting trees and other vegetation in urban areas to help filter air pollution.
- Educating the public about the dangers of air pollution and how to reduce their exposure.
- By taking these steps, the government can help to improve air quality and protect the health of its citizens.

Relevance to the Prelims and Mains syllabus under the following topics:

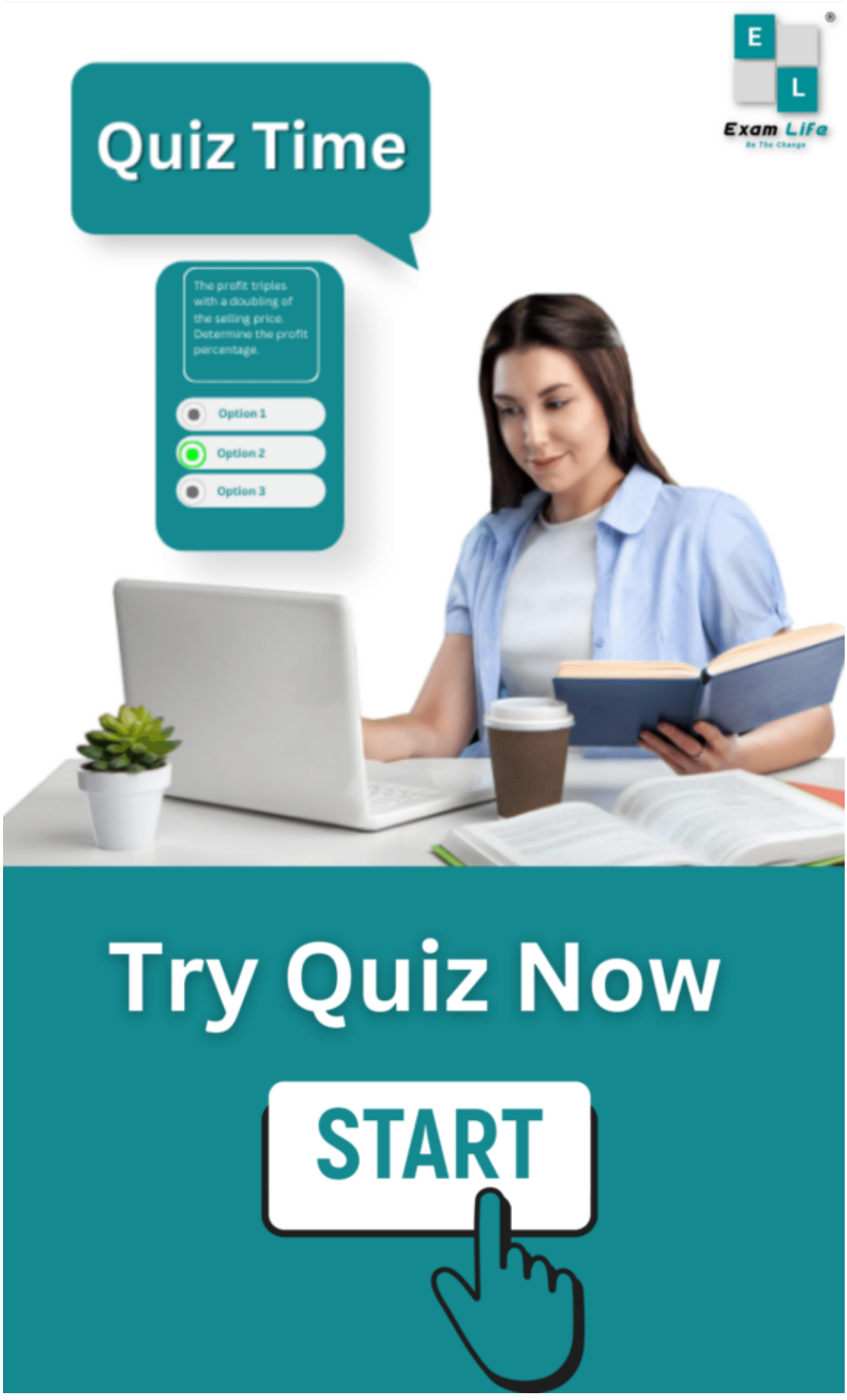
Air Quality Index (AQI) is covered in the following topics in the UPSC Prelims and Mains:

UPSC Prelims

- Environment and Ecology
- Science and Technology
- Current Affairs

UPSC Mains

- Environment and Ecology
- Science and Technology
- General Studies Paper 3: Economy and Development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The profit triples with a doubling of the selling price. Determine the profit percentage.
Option 1
Option 2
Option 3
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