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What is the news?

- The Indian Institute of Technology Kanpur (IIT Kanpur) has put out a creative solution to the ongoing air pollution crisis in Delhi: artificial rainfall.

- This method, sometimes referred to as “cloud seeding,” is sprinkling salts or silver iodide into clouds to encourage the development of raindrops. It is anticipated that the precipitation that follows would remove air pollutants, offering a brief respite from the oppressive haze.

Artificial Rainfall: What Is It?

- Another name for artificial rain is cloud seeding.
- Cloud seeding is the process of dispersing substances into clouds to stimulate the formation of precipitation.

” Three primary techniques exist for cloud seeding:

- **Static cloud seeding:** In this technique, a chemical, like silver iodide, is applied from the ground up into clouds. In order to create more ice crystals and, eventually, snowflakes or showers, moisture might condense around the crystal that the silver iodide offers.
- **Dynamic cloud seeding:** In this technique, seeding agents are distributed into clouds via aeroplanes. Flares, explosions, and generators can all release the seeding chemicals. Increasing the vertical air currents within the cloud is the aim of dynamic cloud seeding, which may result in increased precipitation.
- **Hygroscopic cloud seeding:** This technique includes distributing salts into clouds, including sodium chloride. The salts enlarge because they draw moisture to them. The bigger salt particles may then descend to the earth in the form of rainfall.

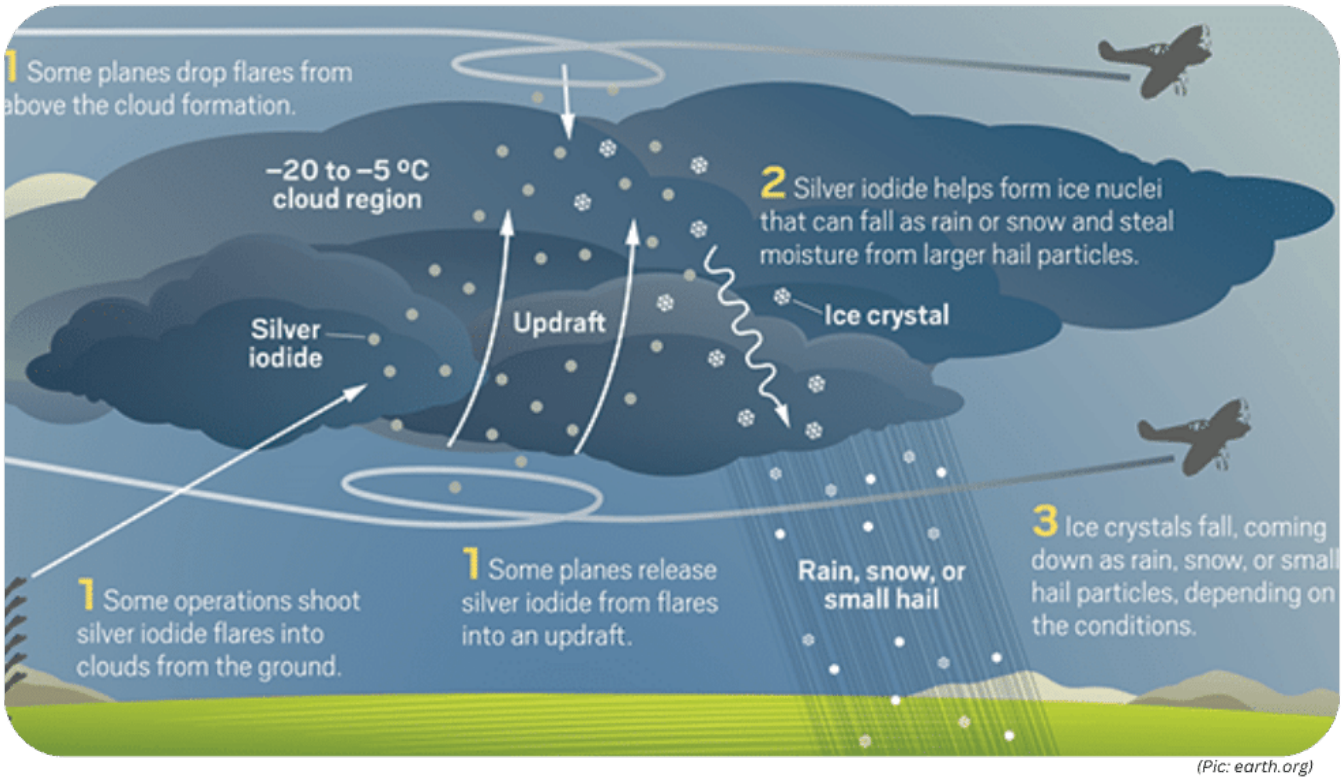
Concept Behind Artificial Rainfall:

- The concept of artificial rainfall revolves around the principles of cloud physics and meteorology. Here’s a simplified explanation of the process:

    - **Identifying Clouds:** Scientists use advanced

weather monitoring systems to identify suitable clouds that have the potential to produce rain.

- **Cloud Seeding Agents:** Cloud seeding involves introducing seeding agents into the identified clouds. Commonly used substances include silver iodide, potassium iodide, or liquid propane. These substances serve as nuclei around which water droplets can form.
- **Nucleation Process:** The seeding agents act as nuclei, promoting the condensation of water vapor into droplets. This process creates larger water droplets that eventually fall as precipitation.
- **Rainfall:** The induced nucleation process results in the formation of rain, which helps in removing suspended particles, including pollutants, from the atmosphere.



(Pic: earth.org)

Possible Advantages of Artificial Rainfall in Delhi:

The following are some possible advantages of artificial rainfall in addressing Delhi's air pollution issue:

- **Temporary Pollution Reduction:** Particulate matter, dust, and smoke are just a few of the airborne pollutants that rainwater efficiently purges. Severe pollution outbreaks can be immediately relieved by artificial rains.
- **Suppression of Dust Resuspension:** When precipitation wets the ground, dust particles are less likely to be easily agitated by wind and re-enter the atmosphere. This contributes to longer-lasting, cleaner air conditions.
- **Hazardous Pollutant Mitigation:** Rainfall can also reduce the adverse effects of pollutants such as nitrogen oxides and sulphur dioxide on human health by removing them from the atmosphere.

Challenges and Considerations:

Even if creating artificial rainfall could help with Delhi's pollution problem, there are several issues and things to keep in mind when using this method:

- **Efficacy and Timing:** A number of variables, such as cloud type, temperature, and wind speed, affect how effective cloud seeding is. It’s not always feasible to ensure that rainfall induction will be successful.
- **Impact on the Environment:** Research is currently being done on cloud seeding’s long-term effects on the environment. There have been some worries expressed over possible changes to biological systems and natural precipitation patterns.
- **Limited Solution:** Unlike other temporary solutions, artificial rainfall does not address the underlying causes of Delhi’s air pollution, which include construction dust, industrial activity, and vehicle emissions.

Here are some instances of how cloud seeding is put to use:

- **Project Sky River: China** has been actively using cloud seeding to increase rainfall, particularly in arid regions. In 2016, the “Sky River” project aimed to boost precipitation in the Tibetan Plateau. Aircraft and ground-based generators dispersed silver iodide into clouds to encourage rain formation.
- **Research and Development: Due to its arid climate, the UAE** has invested in cloud seeding to augment water resources. The UAE Research Program for Rain Enhancement Science focuses on advancing cloud seeding techniques. In 2015, the country allocated funds to deploy aircraft for cloud seeding operations.

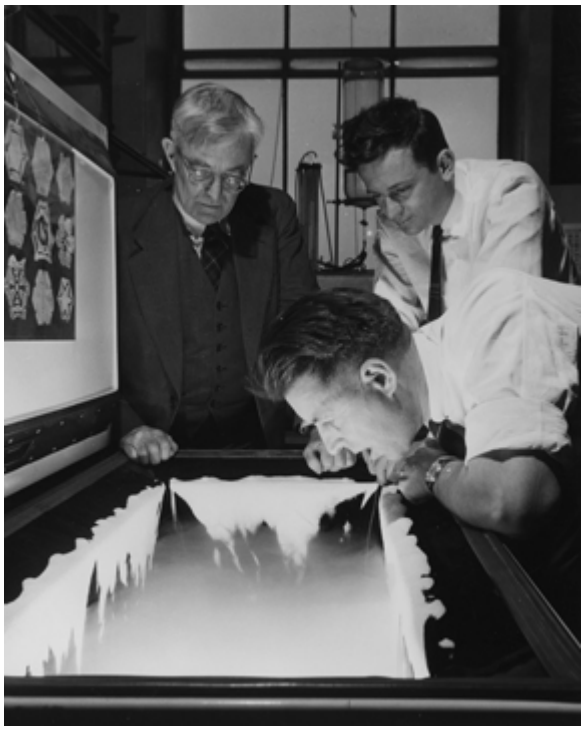
- **Colorado River Basin: Several states in the western United States,** facing water shortages, have implemented cloud seeding programs. Colorado, for instance, has been conducting cloud seeding operations in the Colorado River Basin. Silver iodide is released into clouds from ground-based generators to increase snowfall in mountainous areas, ultimately contributing to water supply.
- **Snowy Mountains Cloud Seeding Program: Australia** has also utilized cloud seeding to enhance precipitation. The Snowy Mountains Cloud Seeding Program, initiated in the 1950s, releases seeding agents into clouds over the Snowy Mountains. The goal is to increase snowfall, which benefits water storage and hydroelectric power generation.
- **Maharashtra and Karnataka: In India,** states like Maharashtra and Karnataka have implemented cloud seeding projects to address water scarcity. Aircraft disperse silver iodide or other seeding agents over clouds to stimulate rain. These initiatives aim to replenish water reservoirs and provide relief to drought-affected regions.
- **Moscow: Russia** has experimented with cloud seeding in urban areas to reduce the impact of air pollution. By inducing rain, the process helps to cleanse the atmosphere of pollutants. Moscow has explored this technique to improve air quality and mitigate the effects of smog.

Cloud Seeding's Dawn: A Search for Rainfall:

- Cloud seeding, another name for artificial rainfall, is a notion that dates back to the late 1800s. Motivated by the goal of mitigating drought conditions and improving agricultural yields, early pioneers started experimenting with several techniques to create precipitation from clouds.
- Scientists in Europe and the United States tried shooting cannons into clouds or setting explosive combinations on fire in the late 1800s in an attempt to create rainfall. Even though these approaches were unsuccessful, they set the stage for future studies on cloud physics and weather modification strategies.

Unlocking the Secrets of Cloud Formation: The Role of Condensation Nuclei:

- A significant breakthrough in cloud seeding technology occurred in the 1920s when Australian meteorologist Irving Langmuir and American chemist Vincent Schaefer discovered the role of condensation nuclei in cloud formation. They found that introducing substances with a crystalline structure similar to ice, such as silver iodide or sodium chloride, into clouds could significantly enhance precipitation.



(Pic: mettech)

The Development of Contemporary Cloud Seeding Methods:

- The sophistication of cloud seeding techniques increased with the study of condensation nuclei. In order to boost precipitation, researchers started utilising aircraft to distribute seeding substances into clouds. They targeted particular cloud forms and meteorological circumstances for this purpose.
- Experiments on cloud seeding conducted in the 1940s in the US, Australia, and other nations showed encouraging outcomes. There have been instances where rainfall increases of up to 15% have been recorded, especially for cumulus clouds, which are distinguished by their puffy, spherical shape.

Expanding Applications and Ongoing Research:

- Cloud seeding has been applied in various regions around the world, primarily to mitigate drought conditions and enhance agricultural production. However, its use has also extended to other areas, such as suppressing hailstorms and reducing the intensity of wildfires.
- Despite its potential benefits, cloud seeding remains an evolving field of research. Scientists continue to refine seeding techniques, study the long-term environmental impacts, and investigate the effectiveness of cloud seeding in different regions and under varying atmospheric conditions.

A Balancing Act: Benefits, Challenges, and Considerations:

While artificial rainfall offers a promising solution for addressing drought and reducing air pollution, it is crucial to weigh its benefits against potential challenges and considerations:

- **Efficacy and Timing:** The effectiveness of cloud seeding depends on various factors, including cloud type, temperature, and wind conditions. It is not always possible to guarantee successful rainfall induction.
- **Environmental Impact:** The long-term environmental impact of cloud seeding is still being studied. Some concerns have been raised about potential disruptions to natural precipitation patterns and

ecological systems.

- **Limited Solution:** Artificial rainfall is a temporary measure and does not address the root causes of air pollution or drought. It should be used in conjunction with long-term strategies to address these underlying issues.
- **Ethical Considerations:** The potential for cloud seeding to affect precipitation patterns in neighboring regions raises ethical concerns about the equitable distribution of water resources.
- **Regulatory Framework:** Clear guidelines and regulations are needed to govern the use of cloud seeding, ensuring responsible and sustainable practices.

QuizTime:

Which of the following substances is most commonly used for cloud seeding?

(a) Silver iodide
(b) Sodium chloride
(c) Dry ice
(d) All of the above

- Answer:
- (d) All of the above
- Explanation: Silver iodide, sodium chloride, and dry ice are all commonly used for cloud seeding. Silver iodide is the most effective seeding agent for warm clouds, while sodium chloride is more effective for cold clouds. Dry ice is used to cool clouds, which can help to promote precipitation.

Which of the following is the primary goal of cloud seeding?

(a) To increase precipitation
(b) To reduce hailstorms
(c) To suppress wildfires
(d) All of the above

- Answer:
- (d) All of the above
- Explanation: Cloud seeding can be used for a variety of purposes, including increasing precipitation, reducing hailstorms, suppressing wildfires, and mitigating air pollution.

Which of the following is a potential concern about the environmental impact of cloud seeding?

(a) Disruption of natural precipitation patterns
(b) Alteration of cloud microphysics
(c) Introduction of chemical pollutants into the atmosphere
(d) All of the above

- Answer:
- (d) All of the above
- Explanation: Cloud seeding has the potential to disrupt natural precipitation patterns, alter

cloud microphysics, and introduce chemical pollutants into the atmosphere. These potential impacts need to be carefully considered before cloud seeding is used on a large scale.

Mains Questions:

Discuss the potential benefits and challenges associated with cloud seeding as a strategy for mitigating drought and air pollution.

Model Answer:

Benefits of cloud seeding:

- Increased precipitation: Cloud seeding can increase precipitation by providing condensation nuclei around which water droplets can form. This can help to alleviate drought conditions and increase water supplies for agriculture and other uses.

- Reduced air pollution: Cloud seeding can help to reduce air pollution by washing pollutants out of the atmosphere. This can improve air quality and public health.
- Suppression of hailstorms: Cloud seeding can be used to suppress hailstorms by promoting the formation of smaller ice crystals, which are less likely to grow into large hailstones.

Challenges of cloud seeding:

- Efficacy: The effectiveness of cloud seeding depends on a variety of factors, including cloud type, temperature, and wind conditions. It is not always possible to guarantee successful rainfall induction.
- Environmental impact: The long-term environmental impact of cloud seeding is still being studied. Some concerns have been raised about potential disruptions to natural precipitation patterns and ecological systems.
- Limited solution: Cloud seeding is a temporary measure and does not address the root causes of drought or air pollution. It should be used in conjunction with long-term strategies to address these underlying issues.
- Ethical considerations: The potential for cloud seeding to affect precipitation patterns in neighboring regions raises ethical concerns about the equitable distribution of water resources.
- Regulatory framework: Clear guidelines and regulations are needed to govern the use of cloud seeding, ensuring responsible and sustainable practices.

Question 2: Evaluate the role of cloud seeding as a potential climate change adaptation strategy. Discuss the advantages and limitations of this approach.

Model Answer:

Advantages of cloud seeding as a climate change adaptation strategy:

- Increased water availability: Cloud seeding can potentially increase water availability in regions that are experiencing drought due to climate change.
- Reduced drought impacts: Cloud seeding can help to mitigate the impacts of drought on agriculture, ecosystems, and human populations.
- Suppression of wildfires: Cloud seeding can be used to suppress wildfires, which are becoming more frequent and intense due to climate change.
- Mitigation of air pollution: Cloud seeding can help to reduce air pollution, which is exacerbated by climate change.

Limitations of cloud seeding as a climate change adaptation strategy:

- Limited effectiveness: The effectiveness of cloud seeding is variable and depends on a variety of factors, including cloud type, temperature, and wind conditions.
- Potential environmental impacts: The long-term environmental impacts of cloud seeding are still

being studied and may include disruptions to natural precipitation patterns and ecological systems.

- Short-term solution: Cloud seeding is a temporary measure and does not address the root causes of climate change, such as greenhouse gas emissions.
- Ethical considerations: The potential for cloud seeding to affect precipitation patterns in neighboring regions raises ethical concerns about the equitable distribution of water resources.
- Need for further research: More research is needed to fully understand the potential benefits and risks of cloud seeding as a climate change adaptation strategy.

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

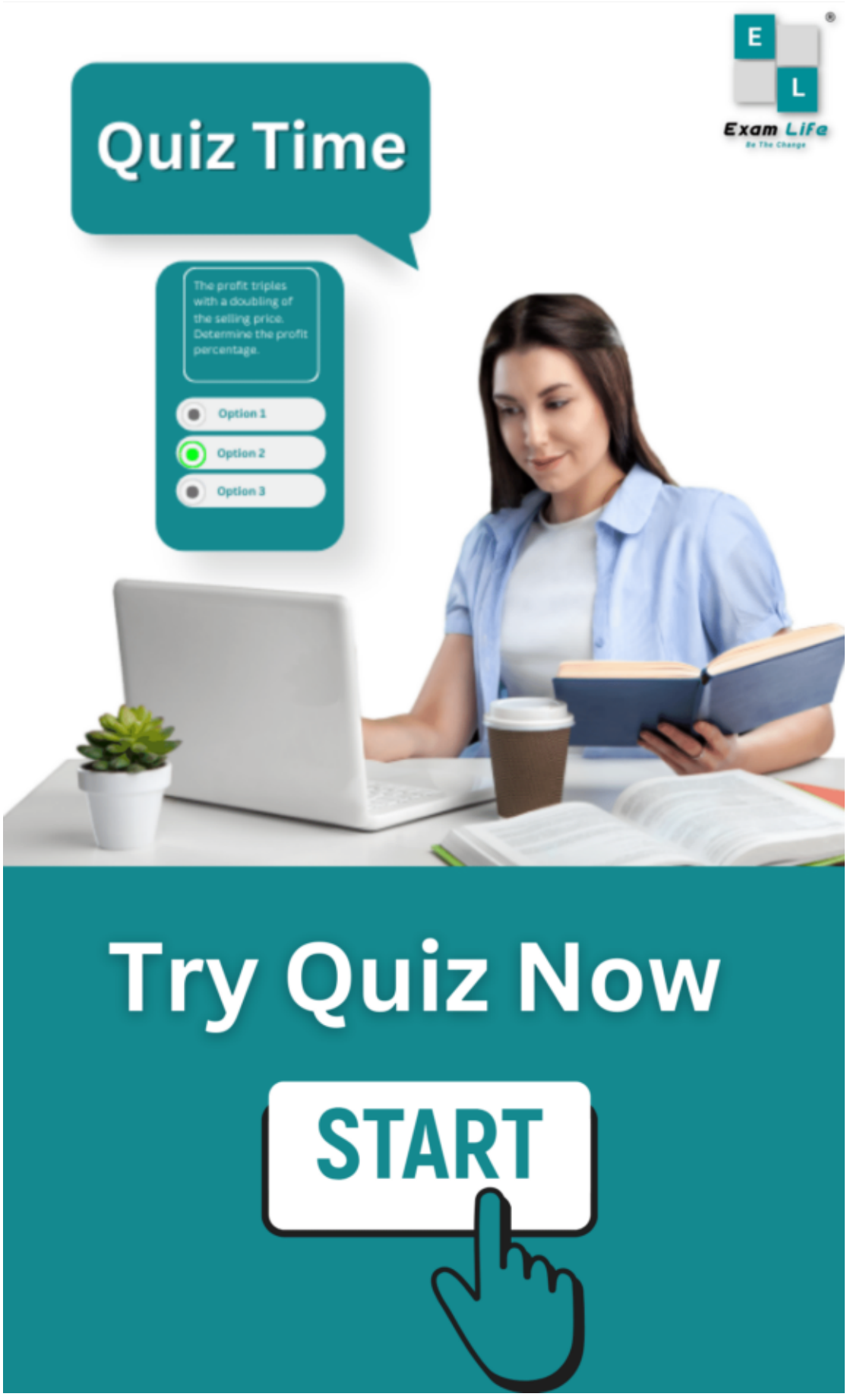
UPSC Prelims

- Cloud seeding is typically covered in the General Science section of the UPSC Prelims syllabus. Questions on cloud seeding may focus on the basic principles of the technique, its applications, and

its potential benefits and limitations.

UPSC Mains:

- Cloud seeding is more extensively covered in the UPSC Mains syllabus, particularly in the General Studies Paper III (Environment and Ecology). Questions on cloud seeding in Mains may require a more in-depth understanding of the science behind the technique, its environmental impacts, and its role in climate change adaptation strategies.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