Aviation and its Impact on Emissions

For Prelims: **Regional Connectivity Scheme-UDAN**, **Open Sky Agreement**, **Carbon Neutrality**

For Mains: Emission from aviation sector, Key Challenges Related to it and Way forward, Transformation of India's aviation sector, Government Policies & Interventions

Source: TH

Why in News?

A study published in ***journal Nature*** found that the **aviation sector** is one of the top global contributors to **greenhouse gas emissions**, with **private jets** having a much higher **carbon footprint** per passenger.

- India's private aviation sector is in its early stages but is experiencing rapid growth, driven by the country's growing wealth.

What is the State of Emission from the Aviation Sector?

- **Aviation Sector:**
  - As per **International Energy Agency (IEA)**, aviation contributed **2% of global energy-related CO_2 emissions in 2022**, with emissions reaching around **800 Mt CO_2,** approximately 80% of **Covid-19 pandemic** levels.
    - Aviation emissions have **grown faster than rail, road, or shipping** in recent decades.
  - The aviation sector would rank among the **top 10 emitters worldwide** if it were treated as a **single nation.**
- **Emissions from Private Aviation:** The study found that emissions from private aviation **increased by 46% between 2019 and 2023.**
  - Private jets emit **5 to 14 times more CO2** per passenger than commercial flights and are **50 times more polluting than trains** on a per-passenger basis.
  - It also releases **nitrogen oxides (NOx)** and other green-houses gases such as vapor trails, which further exacerbate the environmental impact.

Growth in Private Aviation:

- **Global:** The number of private jets increased from 25,993 in December 2023 to **26,454 in February 2024**, contributing to the rise in emissions.
  - Each private flight on average emits approximately **3.6 tonnes of CO2,** intensifying **global warming.**
- **India:** As of March 2024, India has **112 registered private planes.**
  - While this number is relatively small compared to global leaders like the US and Malta, it

places India among the **top 20 countries** in terms of private aircraft ownership.
    - India has **one private jet per 1 lakh people**, significantly lower than countries like Malta (46.51 per lakh) and the US (5.45 per lakh).
    - The increasing **number of billionaires in India (third highest globally)** and the growing millionaire population are key drivers of the demand for private jets.

What are the Potential Solutions to Decarbonize the Aviation Sector?

- **Sustainable Aviation Fuels (SAFs):** SAFs (tested by airlines like SpiceJet and Air Asia) are **bio-based or waste-derived fuels** that are chemically similar to conventional jet fuel but have a **significantly lower carbon footprint**.
    - **Potential Benefits:**
        - **Carbon Emission Reduction:** SAFs can reduce lifecycle carbon emissions by up to **80%,** depending on the feedstock and production method.
        - **Compatibility:** SAFs are **drop-in fuels** that can be **used in existing aircraft engines** and infrastructure **without major modifications**, offering a near-term solution for emission reduction.
        - **Diverse Feedstocks**: SAF production can leverage a wide range of feedstocks (like algae, agricultural residues, waste oils, or municipal solid waste), **reducing dependence on fossil fuels and offering flexibility** in supply chains.
    - **Challenges:**
        - **High Cost:** SAFs are currently **more expensive than conventional jet fuels**, making them less competitive in the market.
        - **Limited Production:** The global production capacity of SAFs remains limited, and scaling up production to meet the demand of the aviation industry requires **significant investment and infrastructure development.**
        - **Sustainability**: While SAFs reduce emissions, their production must be sustainable, considering factors like land-use changes, water use, and biodiversity.
- **Battery-Electric Propulsion:** It involves using **electricity stored in batteries** to power aircraft engines, **replacing conventional jet engines** with electric motors to reduce greenhouse gas emissions.
    - **Potential Benefits:**
        - **Zero Emissions:** Battery-electric aircraft produce no direct emissions, contributing to a clean, carbon-neutral future for short-haul flights.
        - **Energy Efficiency:** Electric motors are **more efficient than combustion engines,** converting more energy from the battery into thrust.
        - **Noise Reduction:** Electric propulsion reduces noise pollution, making it ideal for urban and regional airports.
    - **Challenges:**
        - **Battery Limitations:** Current battery technology is **not suitable for long-haul flights** due to limitations in energy density.
        - **Weight and Size:** Batteries are **heavy and take up significant space**, which limits the size and payload capacity of electric aircraft.
        - **Charging Infrastructure:** The widespread deployment of charging infrastructure at airports is necessary and **requires significant investment and coordination.**
- **Hydrogen**: Hydrogen fuel offers a **high energy density and emits only water vapor** when combusted, making it a clean fuel alternative.
    - Both **hydrogen combustion** (40% efficiency) and **hydrogen fuel cells** (45-50% efficiency) are under active research.
    - **Potential Benefits:**
        - **Higher Energy Density:** Hydrogen has **three times the gravimetric energy density of kerosene**, making it suitable for powering larger aircraft and longer flights.
            - Gravimetric energy density is the available energy per unit mass of a substance.

        - **Clean Emissions**: When combusted or used in fuel cells, hydrogen only **produces water vapor,** making it a clean alternative to fossil-based jet fuels.
    - **Challenges:**
        - **Hydrogen Storage**: Hydrogen's low volumetric energy density necessitates large, **heavy storage tanks,** challenging aviation's need for compact, lightweight solutions.
            - Liquid hydrogen offers higher density but introduces additional complexities, making efficient storage difficult.
        - **Infrastructure Development**: Establishing refueling infrastructure at airports and ensuring the safe global transportation of hydrogen is challenging due to its **high flammability.**
            - The **need for specialized safety measures and skilled labor** increases costs.
        - **Aircraft Redesign**: Hydrogen combustion requires **partial aircraft redesign,** while fuel cells necessitate complete overhauls, including **modifications to fuel tanks, delivery systems, and storage**.
            - This demands significant **technical expertise and substantial funding for retrofitting existing aircraft.**

What are India's Initiatives for Making Air Travel Sustainable?

- **Policy Initiatives:** The Indian government launched the **UDAN Scheme (Ude Desh ka Aam Nagrik)** scheme to improve rural air connectivity and **NABH (Nextgen Airports for Bharat Nirman)** to expand airport capacity.
- **Sustainable Aviation Fuels (SAFs)**: Indian airlines have tested SAFs, with SpiceJet using a blend of **jatropha oil** in 2018 and AirAsia using SAF in 2023.
- **Ethanol for Aviation**: India's ethanol production supply chain could be a feasible medium-term solution for aviation fuel.
    - Using **surplus sugar to produce ethanol for aviation fuel** could meet **15-20% of India's aviation fuel demand by 2050,** though care is needed to avoid land-use changes and groundwater depletion.

India's Initiatives Related to Aviation Industry

- **National Civil Aviation Policy, 2016**
- **Goods and Services Tax (GST)** rate reduced to 5% from 18% for domestic **Maintenance, Repair and Overhaul (MRO)** services.
- **Open Sky Agreement**
- **Digi Yatra**

Way Forward

- **Promote Sustainable Aviation Fuels (SAFs):** Scale up SAF production through public-private partnerships to reduce costs and increase availability.
- **Develop Hydrogen and Electric Propulsion:** Invest in hydrogen-powered aircraft and electric propulsion technologies, focusing on storage solutions, infrastructure, and aircraft redesign.
- **Carbon Offset Initiatives:** Implement carbon offset programs, such as the **ICAO Carbon Emissions Calculator (ICEC)**, to assess and mitigate the environmental footprint of aviation activities.
- **Strengthen Infrastructure:** Build infrastructure for SAF production, hydrogen refueling, and electric charging at airports with a focus on safety and efficiency.
- **Policy and Regulatory Support:** Implement policies like **carbon pricing**, tax incentives, and stringent emissions targets to promote the adoption of green technologies in aviation.
- **Carbon Offset Programs:** Establish robust carbon offset programs, such as the ICAO Carbon Emissions Calculator (ICEC), to mitigate emissions during the transition.
- **Stakeholder Collaboration:** Encourage collaboration between airlines, manufacturers, and

regulators to overcome technological and financial barriers to sustainable aviation.

Conclusion

The growth of private aviation, both globally and in India, challenges climate change efforts. While aviation is vital to the global economy, prioritizing decarbonization through innovation, policy, and sustainability is crucial. As India's private aviation sector expands, it must focus on low-carbon technologies and responsible air travel to minimize environmental impact.

Drishti Mains Question:

Discuss the potential solutions for decarbonizing the aviation sector, including the role of SAFs, hydrogen, and electric propulsion.

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Mains

Q. Examine the development of Airports in India through joint ventures under Public–Private Partnership (PPP) model. What are the challenges faced by the authorities in this regard? **(2017)**