Sustainable Nitrogen Management: FAO

For Prelims: **Food and Agriculture Organization**, **Nitrogen Pollution**, **Nitrogen**, **Livestock**, **Haber-Bosch Process**, **Ammonium**, **Air Pollution**, **Greenhouse Gas**, **Eutrophication**, **Ozone Layer**, **Soil Health**, **Dead Zones**, **Algal Blooms**, **Ground Level Ozone**, **Green Revolution**, **Planetary Boundaries**, **Paris Agreement**, **Bioeconomy**, **Food Security**, **Sustainable Development Goals**.

For Mains: Status and ways to manage nitrogen pollution, nitrogen use efficiency.

Source: DTE

Why in News?

The **Food and Agriculture Organization** released a report titled **Sustainable nitrogen management in agrifood systems** highlighting the **state of nitrogen pollution**.

- This report gives a comprehensive overview of the **role of nitrogen use** and **consequent challenges** in agrifood systems.

What are the Key Highlights of the Report?

- **Current Nitrogen Emissions:** Humans add around **150 teragrams (Tg) (1 Tg = 1 million tonnes)** of reactive nitrogen to Earth's land surface annually through **agriculture and industry**, with climate change potentially increasing this to **600 Tg per year by 2100.**
  - This is **more than double the pre-industrial nitrogen rate**, contributing to environmental nitrogen pollution.
- **Major Sources of Nitrogen Loss: Livestock** is the **largest contributor** to nitrogen emissions, responsible for **about one-third** of total nitrogen emissions from human activities.
  - Other major contributors include **synthetic fertilizers, land-use change**, and **manure emissions**.
- **Exceedance Nitrogen Boundaries**: **Global nitrogen flows** have surpassed the **planetary boundaries** (nitrogen use has **exceeded the environmental limits** within which humanity can safely operate).
  - The degree of nitrogen exceedance has **dramatically increased** since **2015**.
- **Global Crop Yield Trends**: **Global crop yield** has risen steadily, from **19 kg of nitrogen per hectare per year** in 1961 to **65 kg N/ha/year** in 2022.
  - Despite the rise in crop yield, NUE **fluctuated,** dropping from **56% in 1961** to **40% in the 1980s** before improving back to **56% in 2022**.
- **Regional Differences:**
  - **Asia**: Fertilizer subsidies during the **Green Revolution** increased yields but caused significant nitrogen pollution.
    - **Southeast Asia** saw a significant drop in NUE, from **65% in 1961 to 45% in the 1990s**, before increasing again to **54% in 2022.**
  - **Africa**: Struggles with **low crop yields and nutrient depletion** due to inadequate policies and limited access to fertilizers.

    - **Europe & North America**: Higher NUE achieved through **nutrient management** guidelines and regulations.
        - **North America** experienced a drop in NUE from **65% in 1961 to below 50% in the 1980s**, then saw an increase to **69% in 2022.**
    - **Latin America**: Faces challenges with reliance on **imported fertilizers** and disruptions in supply chains, affecting **nitrogen management.**
- **Variation in NUE at the Crop Level**: NUE varies significantly by crop type:
    - **Soybeans** had an NUE of **80% in 2010**, reflecting high nitrogen use efficiency.
    - **Fruits and vegetables** had **much lower NUE**, around **14%** in 2010, indicating substantial **nitrogen losses** during production.
- **Challenges in Developing Countries**: **Low- and Middle-Income countries** face challenges such as **limited access** to nitrogen fertilizers and soil health degradation.
    - Without addressing nitrogen losses, crop yields are low, and poor **manure management** increases nitrogen emissions.

Note:

- **Planetary Boundaries:** The **planetary boundaries** framework, introduced in **2009** by **Johan Rockstrom** and 28 scientists, defines **Earth's environmental limits** to maintain **stability and biodiversity** for humanity's safe existence.
    - Breaching planetary boundaries raises the risk of **irreversible environmental changes**, threatening Earth's habitability.

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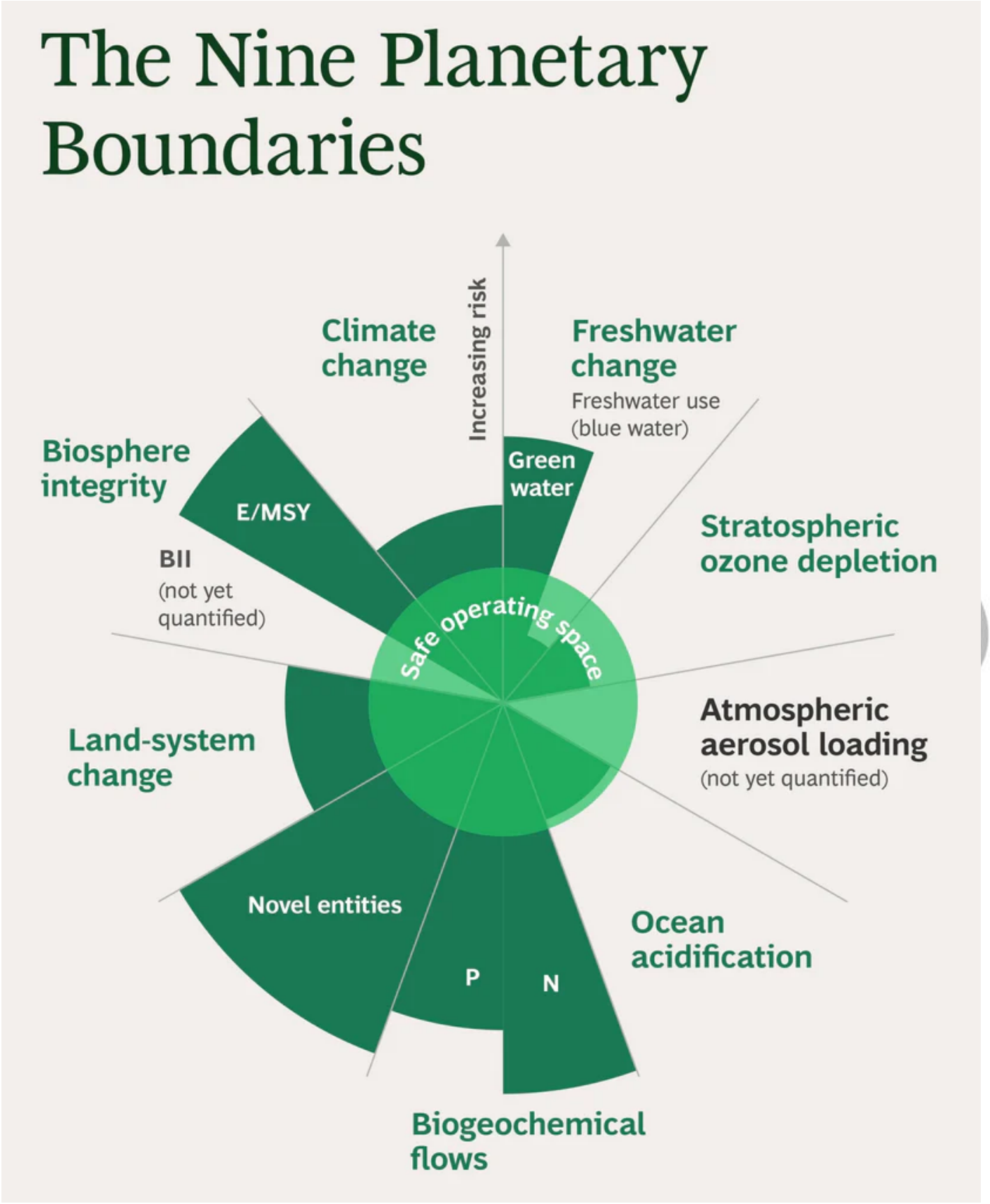

What is Nitrogen Use Efficiency (NUE)?

- **About:** It is used to describe the **efficiency** of a plant in **using applied or fixed**

nitrogen for **biomass production.**
    - It is the **ratio** of **crop yield** to the **nitrogen absorbed** from the soil or fixed by bacteria.
- **Poor NUE:** Poor NUE refers to the **inefficient use of nitrogen** in agriculture, where much of it is **lost to the environment**, causing **pollution and reducing productivity**.
- **Concerns with Poor NUE:** Poor NUE wastes nitrogen fertilizers worth **Rs 1 trillion a year in India** and over **USD 170 billion per year globally**.
    - India is the **2nd largest source of nitrous oxide (N2O)**, a potent greenhouse gas that warms the atmosphere more than carbon dioxide.
    - In 2020, India accounted for nearly **11% of global anthropogenic N2O emissions**, second only to **China at 16%.**

What is Nitrogen Pollution?

- **About Nitrogen:** Nitrogen (N) is a core **building block in amino acids and proteins**, essential for **plant growth and agrifood systems**.
    - Nitrogen is essential for **crop and livestock production**. While **legumes fix atmospheric nitrogen**, most **plants** depend on **soil nitrogen**.
    - The **Haber-Bosch process** converts **inert nitrogen into reactive nitrogen (such as ammonium),** enabling the use of **synthetic fertilizers** that boost crop production.
- **About Nitrogen Pollution: Nitrogen pollution** refers to the excessive presence of nitrogen compounds, particularly in the form of **nitrogen oxides (NOx)** and **nitrates (NO3)**, in the environment.
    - **Nitrogen loss (emission) in the environment** harms **air and water quality,** human health, and biodiversity, impacting both **terrestrial and aquatic ecosystems.**
- **Forms of Nitrogen Loss**:
    - **Air Pollution**: Emissions of **ammonia (NH_3)** and **nitrogen oxides (NOx)** contribute to **air pollution**.
    - **Greenhouse Gas Emissions**: **Nitrous oxide (N_2O)** is a potent **greenhouse gas (GHGs)** that contributes to climate change.
    - **Water Pollution**: **Nitrate leaching** causes **eutrophication and acidification** of water bodies, harming aquatic ecosystems and water quality.
- **Concerns with Nitrogen Pollution:** In the **past 150 years,** human-driven reactive nitrogen flows have **increased tenfold**.
    - Each year, **200 million tonnes of reactive nitrogen (80%)** are lost to the environment, contaminating **soil, rivers, lakes, and the air.**
- **Effects:**
    - **Global Warming and Ozone Layer:** Nitrous oxide is **300 times** more powerful than **methane and carbon dioxide** as a greenhouse gas and is the **largest human-made threat** to the **ozone layer.**
    - **Biodiversity:** Nitrogen pollution can **degrade soils** by making them **acidic** through excessive use of synthetic fertilizers, **harming soil health** and reducing productivity.
        - Nitrogen pollution can create **dead zones** in the ocean and cause **toxic algal blooms** to spread in **marine ecosystems**.
    - **Air:** Nitrogen oxides from coal plants, factories, and vehicle exhausts can cause **smog** and **ground-level ozone.**
        - **Agricultural ammonia** and vehicle **exhaust emissions** create harmful particulates that worsen respiratory diseases.

What are Key Proposals to Tackle Nitrogen Pollution as per the Report?

- **Fertilizer Industry Interventions**: Reduce **GHGs emissions** in nitrogen fertilizer **production** and **minimize** losses during **storage, transport, and application.**
    - Support the cultivation of **leguminous crops** such as **soybeans and alfalfa** to naturally fix atmospheric nitrogen.
    - Implement spatial planning to **redistribute livestock** and reduce the concentration of livestock in specific regions to **avoid nitrogen hotspots**.
- **Integration with Climate Goals**: Integrate **sustainable nitrogen management** into **nationally determined contributions (NDCs)**, setting targets to reduce nitrous oxide emissions from agrifood systems in line with the **Paris Agreement**'s 1.5°C goal.

    - Establish **national commitments** to reduce nitrogen pollution, particularly **ammonia and nitrates**, to meet global biodiversity goals.
- **Circular Bioeconomy Principles**: **Circular bioeconomy** can improve resource use efficiency and NUE by **reducing food losses, recycling waste**, and using livestock to convert biomass and waste streams into **usable resources**.
    - Promote the recycling and treatment of food waste unsuitable for human consumption as livestock feed.
- **Sustainable Nitrogen Management**: Encourage **public and private sector** investment in **high-efficiency, low-emission mineral fertilizers**.
    - Promote the **recycling of organic residues** to enhance system efficiency and reduce resource waste.
    - Techniques to improve NUE include **better fertilization strategies, manure management**, and integrating livestock into cropping systems.
- **Balancing Nitrogen's Dual Role**: Effective policies must reconcile **nitrogen's role as a nutrient and a pollutant** to mitigate its environmental impact while ensuring **food security.**

Conclusion

Sustainable nitrogen management is crucial for achieving the **Sustainable Development Goals by 2030**, particularly those related to **hunger, health, clean water, sustainable production and consumption, climate action, and preserving life on land and underwater**. Improving nitrogen use efficiency across the **agri-food chain** and **reducing nitrogen loss** can help increase food production in low- and middle-income countries by allowing more nitrogen resources to achieve their intended purpose, improve health by **reducing harmful emissions, and protect water bodies from pollution.**

Drishti Mains Question:

India is the second-largest contributor to nitrous oxide emissions globally. Examine the causes and suggest policy measures for sustainable nitrogen management in India.

UPSC Civil Services Examination, Previous Year Question:

Prelims

Q. Consider the following: (2019)

1. Carbon monoxide
2. Methane
3. Ozone
4. Sulphur dioxide

Which of the above are released into the atmosphere due to the burning of crop/biomass residue?

(a) 1 and 2 only

(b) 2, 3 and 4 only

(c) 1 and 4 only

(d) 1, 2, 3 and 4

Ans: (d)

Q. Consider the following statements: (2019)

1. Agricultural soils release nitrogen oxides into the environment.
2. Cattle release ammonia into the environment.
3. Poultry industry releases reactive nitrogen compounds into the environment.

Which of the statements given above is/are correct?

(a) 1 and 3 only

(b) 2 and 3 only

(c) 2 only

(d) 1, 2 and 3

Ans: (d)

Mains

Q. Describe the key points of the revised Global Air Quality Guidelines (AQGs) recently released by the World Health Organisation (WHO). How are these different from its last update in 2005? What changes in India's National Clean Air Programme are required to achieve revised standards? (2021)

Q. Sikkim is the first 'Organic State' in India. What are the ecological and economical benefits of Organic State? (2018)