

Nature-Based Solutions and Climate-Resilient Agriculture

Mains: GS III – Environment

Why in News?

*Climate change is increasingly affecting agricultural systems through rising temperatures, erratic monsoons and frequent extreme weather events and in this context, **Nature-based Solutions (NbS)** and **Climate-Resilient Agriculture (CRA)** have emerged as sustainable approaches to strengthen the resilience of farming systems.*

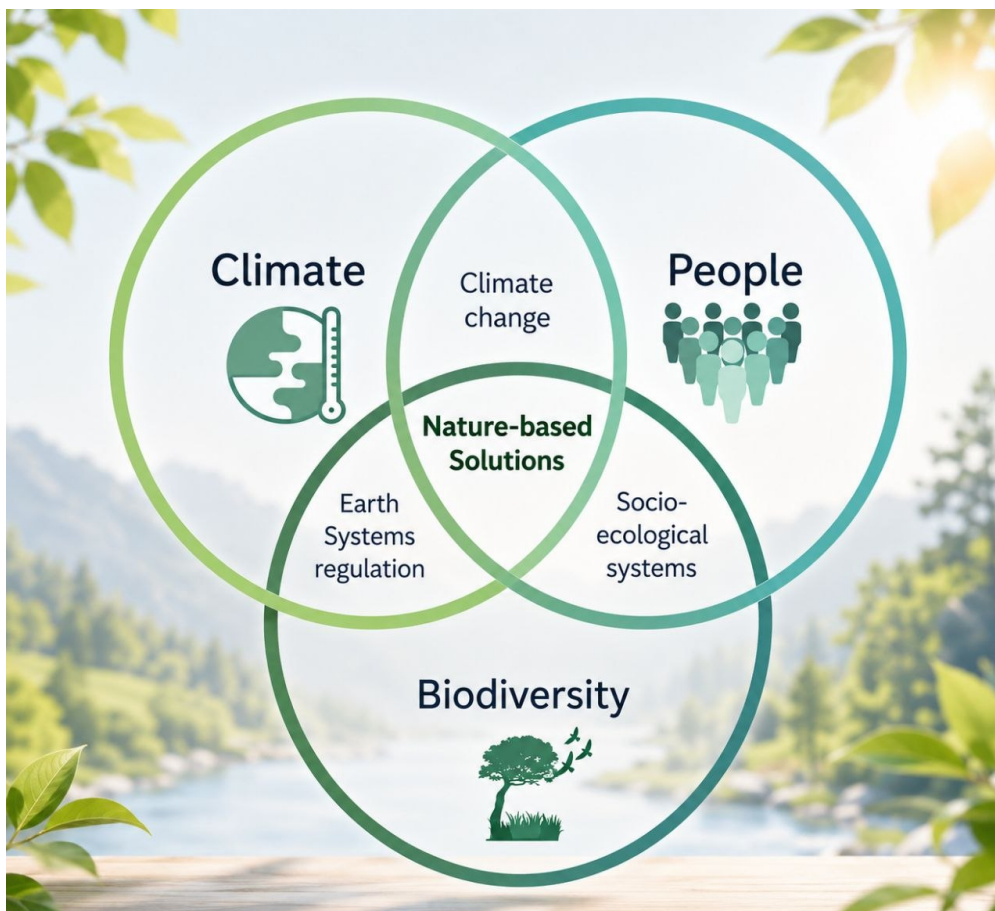
Why Indian agriculture is vulnerable to climate change?

- **Domination of agriculture** – Agriculture remains central to India's economy and rural livelihoods.
- It supports the livelihoods of about **58% of India's population**, employs nearly **46.1% of the workforce** and contributes around **18% of the country's Gross Value Added (GVA)**.
- **Unequal Landholdings** – The average landholding is only **1.08 hectares**, while about **89.4% of marginal and small farmers own less than 2 hectares**.
- This limits their capacity to absorb climate-induced losses and invest in new technologies.
- **Dependent on Rain** – Further, nearly **60% of India's agriculture is rainfed**, accounting for about **40% of total food production**.
- Therefore, fluctuations in monsoon rainfall have a direct impact on agricultural productivity.
- **Climate Change** – Since the 1950s, India has experienced rising average temperatures, declining monsoon precipitation and increases in extreme temperatures, rainfall events, droughts, sea levels and the intensity of severe cyclones.
- Climate change can reduce crop performance by disrupting photosynthesis, altering pest populations, reducing fertiliser use efficiency, affecting soil fertility and causing soil-moisture loss and nutrient imbalance.
- Hence, building climate resilience is essential for both agricultural productivity and national food security.

What is the significance of Climate-Resilient Agriculture?

- **Climate-resilient agriculture** – It refers to farming practices that enable agricultural systems to **adapt to changing climatic conditions, reduce vulnerability to climate-induced shocks and enhance productivity**.
- **Measures** – It involves both adaptation and mitigation measures:

- Selection of appropriate crops and climate-adapted varieties.
- Adjustment of sowing windows and crop duration.
- Adoption of appropriate planting methods.
- Agroforestry.
- Biochar.
- Efficient use of fertilisers, insecticides and pesticides.
- Improved water and soil management.
- The resilience of agriculture also depends on the resilience of social systems.
- Households, communities and regions need access to technical knowledge, government services and institutional support to effectively respond to climatic challenges.



How Nature - based solution helps?

- **Nature-based Solutions** – They provide an important approach to simultaneously address **climate adaptation, climate mitigation and ecosystem restoration**.
- **Components** – In agriculture, they include **regenerative agriculture, conservation agriculture, reduced-tillage or zero-tillage practices, agroforestry and biochar**.
- **Objectives** – Ensuring better adaptation and resilient food production, mitigating climate change, and enhancing nature and biodiversity.
- **Significance** – The importance of NbS extends beyond individual farms.
- They are now part of the emissions-reduction plans of at least **102 nations' Nationally Determined Contributions (NDCs)** under the Paris Agreement.

*A study published in the Proceedings of the National Academy of Sciences suggests that nature-based solutions could deliver **37% of the cost-effective climate mitigation needed to keep global temperature increases below 2°C by 2030.***

- Thus, NbS can help address the interconnected challenges of climate change, agricultural sustainability and global food security.

• **Biochar as a Promising Nature-Based Solution**

- Biochar is one of the important nature-based solutions highlighted for Indian agriculture.
- According to the **Indian Council of Agricultural Research (ICAR)**, biochar is charred biomass produced through slow pyrolysis, in which organic material such as crop residues and wood waste is heated at controlled temperatures of **300-500°C without oxygen**.
- India generates around **350 million tonnes of agricultural waste annually**.
- Proper treatment of this biomass can produce nutrient-rich organic fertilisers and generate about **18,000 MW of power annually**.
- Biochar has high carbon content and can improve **soil fertility, water-retention capacity and nutrient-use efficiency**.
- It can also contribute to carbon sequestration and climate-change mitigation.
- Importantly, it offers a more sustainable alternative to open-field crop-residue burning, thereby helping reduce air pollution and particulate-matter emissions.
- A review by IIT Delhi researchers estimates that biochar could sequester an average of **376.11 megatonnes of CO₂-equivalent in Indian soil**, potentially reducing **41-63% of emissions from agriculture and allied activities**.

What are India's Major Policy Initiatives for Climate-Resilient Agriculture?

- **National Action Plan on Climate Change** - The **National Action Plan on Climate Change (NAPCC)**, launched in **2008**, provides an overarching framework for India's climate-change policies.
- **National Mission for Sustainable Agriculture** - Under the NAPCC, the **National Mission for Sustainable Agriculture (NMSA)** was launched in **2014-15**.
- It seeks to promote climate-resilient agriculture through improved soil health, efficient water use and sustainable farming practices.
- It has initiated schemes such as:
 - Per Drop More Crop
 - Rainfed Area Development
 - Soil Health and Fertility Scheme
 - Mission for Integrated Development of Horticulture
 - Agroforestry
 - National Bamboo Mission
- India also became the **first country to adopt a National Agroforestry Policy in 2014**, followed by the launch of the **National Mission on Natural Farming in 2024**.
- **National Innovations in Climate Resilient Agriculture** - The **National Innovations in Climate Resilient Agriculture (NICRA)** was launched by the Ministry of Agriculture and Farmers Welfare in **2011** and is implemented by the **Indian Council of Agricultural Research (ICAR)**.
- NICRA's vulnerability assessment of **651 agricultural districts** identified **310**

districts as vulnerable, including **109 very highly vulnerable and 201 highly vulnerable districts**. Based on this assessment, District Agriculture Contingency Plans have been prepared for all 651 agricultural districts.

- NICRA also projects that by 2050, yields could decline for **rainfed rice by 20%, wheat by 19.3% and kharif maize by 18%**, while soybean yields could increase by 3-10% by 2030.
- Between 2014 and 2024, ICAR released **2,900 crop varieties**, of which **2,661 were tolerant to one or more biotic or abiotic stresses**, including pests, diseases, water, temperature, humidity and soil-related stresses.

How these measures strengthen adaptation and food security?

- These initiatives strengthen agricultural resilience by promoting **climate-adapted crop varieties**, improving soil and water management, supporting agroforestry and natural farming, and preparing district-level contingency plans.
- Such measures reduce farmers' vulnerability to droughts, irregular rainfall, temperature changes and other climatic shocks.
- Improved soil fertility and **water retention can support productivity**, while diversified and climate-tolerant crops can reduce the risk of crop failure.
- Nature-based solutions additionally help restore ecosystems, **improve soil health**, enhance biodiversity and reduce greenhouse gas emissions. Therefore, adaptation and mitigation can be pursued together.
- By protecting agricultural productivity under changing climatic conditions, these measures contribute to the availability of food and thereby strengthen **food and nutritional security for India's 1.4 billion people**.

What are the challenges and the way forward?

- Technologies such as tolerant crop varieties, genome-edited crops, biofertilisers, biopesticides and water-smart technologies face constraints arising from **lack of awareness, limited access to credit and quality inputs, and high upfront costs**.
- These challenges are particularly significant for small and marginal farmers, they require financial support and initial hand-holding from the government to develop skills in agriculture and allied sectors.
- Therefore, successful climate-resilient agriculture requires greater awareness among stakeholders about climate-change impacts and greater confidence in adopting improved agricultural technologies.
- Farmers, government agencies, research institutions and other organisations must work collaboratively.

What lies ahead?

- Climate change poses a serious challenge to India's agricultural productivity, rural livelihoods and food security.
- However, initiatives such as NAPCC, NMSA, NICRA, agroforestry, natural farming and biochar demonstrate India's efforts to build resilience.
- The integration of **nature-based solutions with climate-resilient agricultural practices** can simultaneously improve soil and water health, strengthen adaptation,

reduce greenhouse gas emissions, restore biodiversity and sustain agricultural productivity.

- With appropriate institutional support, technological access and farmer-oriented implementation, these measures can help increase farmers' incomes, strengthen climate adaptation and ensure food and nutritional security for future generations.

Reference

[The Indian Express| CBS for Solution](#)

