Base Flow Decline in Perennial Rivers

Mains: *GSIII – Environment*

Why in News?

A study by IIT Gandhinagar researchers, published in Water Resources Research, found significant declines in groundwater-fed river flow across nearly 30% of monitoring stations in India between 1961 and 2021.

Key Findings of the Study
• **Analysis** – Six decades of data (1961–2021) from 227 monitoring stations across 18 major river basins using a machine-learning model. • **Observations** – - Nearly 30% of stations recorded significant declines in **baseflow**, while only 8% showed significant increases. - The Ganga and Brahmaputra basins recorded declining baseflow at several monitoring stations, despite their heavy dependence on groundwater. - Sabarmati, Cauvery, South Coast and Pennar basins experienced some of the steepest average declines. - Brahmani, Godavari, Indus, Subarnarekha and some Northeast Coast basins recorded positive average baseflow trends.

What is a Base flow?

- **Baseflow** – It refers to groundwater slowly entering rivers, sustaining their flow even after rainfall stops, particularly during dry seasons.
- **Baseflow Index (BFI)** – Measures the proportion of total river discharge contributed by groundwater, indicating a river's dependence on underground water reserves.
    - Between 1961 and 2021, median BFI exceeded 0.6 in the Ganga, Indus and Brahmaputra basins, indicating over 60% groundwater contribution.
    - Godavari, Krishna, Pennar and Tapti basins recorded BFI values below 0.4, indicating greater dependence on rainfall-driven runoff.
- **Significance of Base flow –**
    - Maintains perennial river flow during dry seasons and supports drinking water and irrigation requirements.
    - Sustains aquatic ecosystems, biodiversity and ecological balance.
    - Regulates groundwater–surface water interactions and improves water availability during rainfall deficits.

What are the Factors Responsible for Declining Baseflow?

- **Anthropogenic Factors**
  - Excessive groundwater extraction for agriculture, industries and urban consumption reduces underground reserves and groundwater discharge into rivers.
  - Urbanisation, deforestation and land-use changes affect infiltration, groundwater recharge and natural river-flow patterns.
  - Dam operations and altered river regimes can influence groundwater–surface water interactions.
- **Climatic Factors**
  - Changing rainfall patterns and declining precipitation reduce groundwater recharge and weaken dry-season river flows.
  - Higher temperatures and evaporation increase water stress, particularly in semi-arid regions.
  - Longer breaks in monsoon rainfall reduce groundwater-fed river contributions.
- **Regional and Climatic Vulnerability**
  - Semi-arid regions experienced the sharpest baseflow declines, with a median BFI of 0.38, due to limited rainfall, higher evaporation and groundwater extraction.
  - Humid regions recorded relatively higher groundwater contributions, reflecting better recharge conditions.
  - Baseflow was significantly lower during El Niño years, with an average standardised anomaly of -0.567, compared to 0.104 during La Niña years.
  - Every five additional monsoon break-days were associated with a 0.231 decline in standardised baseflow anomaly.

What are the Major Concerns related to Base flow decline?

- **Increasing Seasonality of Rivers** – Declining groundwater contributions could transform currently perennial rivers and their tributaries into seasonal water bodies.
- **Water Security** – Reduced dry-season river flows threaten drinking water supplies, irrigation and agricultural productivity.
- **Ecological Degradation** – Lower river flows affect aquatic biodiversity, wetland ecosystems and environmental flows.
- **Groundwater Stress** – Excessive extraction weakens the natural connection between aquifers and rivers, intensifying water scarcity.
- **Regional Inequality** – Semi-arid and groundwater-dependent regions face greater vulnerability to climate variability and water shortages.

What Measures can be taken to restore Base Flow?

- **Groundwater Regulation** – Strengthen sustainable groundwater extraction through aquifer-based management, monitoring and community participation.
- **Aquifer Recharge** – Promote watershed development, rainwater harvesting, restoration of traditional water bodies and artificial groundwater recharge.
- **Sustainable Agriculture** – Encourage micro-irrigation, crop diversification and cultivation of less water-intensive crops.
- **River Basin Management** – Adopt integrated river basin planning by considering

surface water, groundwater and ecological flow requirements together.

- **Ecosystem Restoration** – Protect wetlands, forests, floodplains and natural drainage systems to improve groundwater recharge.
- **Scientific Monitoring** – Expand river-flow monitoring and groundwater assessment using remote sensing, machine learning and hydrological models.
- **Climate Resilience** – Integrate monsoon variability and climate projections into long-term water-resource planning.

What lies ahead?

- India's perennial rivers depend not only on monsoon rainfall but also on healthy groundwater reserves.
- Sustainable aquifer management, ecological restoration and integrated river basin planning are essential to ensure long-term river sustainability and water security.

Reference

Down to Earth|India's perennial rivers losing groundwater flow

