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DAILY NEWS ANALYSIS

10 July

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Decoded

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NO DECISION ON UPDATING NPR

No decision yet on updating NPR along with Census

Vijaita Singh
NEW DELHI

The Centre has not yet decided whether to update the National Population Register (NPR) during the upcoming Census 2027, senior Home Ministry officials have told Census directors during a preparatory meeting.

When questions were raised about the NPR during a two-day conference of the Directors of Census Operations held on July 3 and 4, participants were told that no decision had yet been made regarding the database, and that they would be informed about it at an appropriate time, sources told *The Hindu*.

The conference sessions were addressed by Union Home Secretary Govind Mohan and Registrar-General and Census Commissioner of India Mritunjay Kumar Narayan. This was the first preparatory meeting for the Census, the first phase of which begins in April 2026.

A June 27 letter from the RGI to the Chief Secretaries of all States on preparations for the Census also did not mention the NPR.

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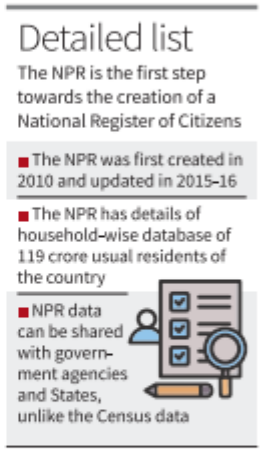
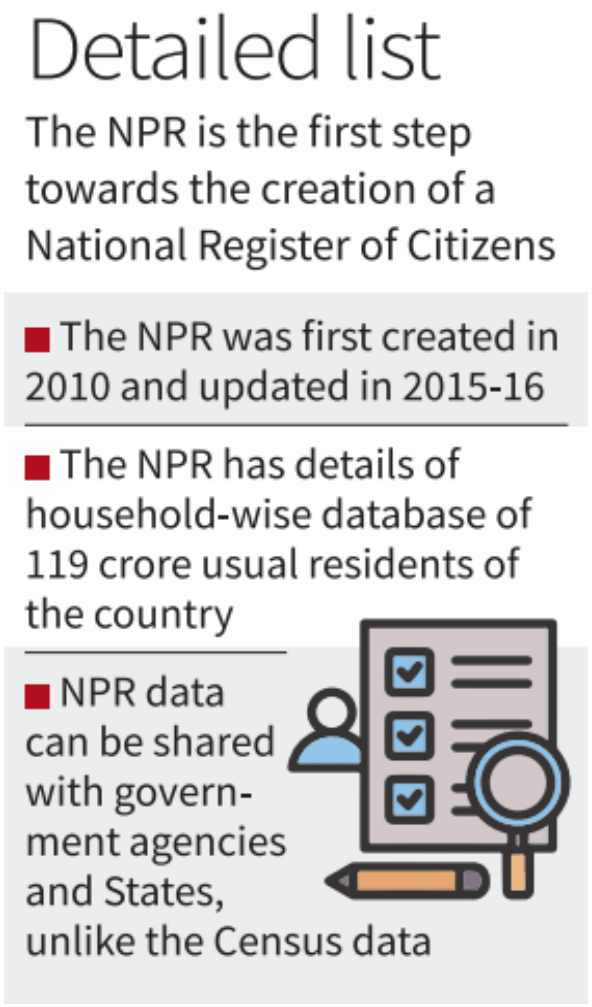




Backdrop: Concerns over updation of National Population Register (NPR) in wake of upcoming Census 2027.
Relevance: GS 1- Population

About the news

- The Centre has not yet decided whether to update the National Population Register (NPR) during the upcoming Census 2027, senior Home Ministry officials have told Census directors during a preparatory meeting.
    - This will be the **first Census using mobile apps** for data collection.
- During a meeting on July 3–4, Census Directors were told that **no final decision** had been made and they would be informed **at an appropriate time**.
- A **June 27 letter** from the Registrar General of India (RGI) to Chief Secretaries of States also made **no mention of NPR**.

National Population Register (NPR)

- The **National Population Register (NPR)** is a **comprehensive database** of all **usual residents** in India.
  - A **"usual resident"** is someone who has lived in an area for **six months or more**, or intends to stay for the next **six months**.
  - **Registration is mandatory** for all usual residents.
- NPR is the **first step toward creating a National Register of Citizens (NRC)**, as per **Citizenship Rules, 2003** under the **Citizenship Act, 1955**.
- **Timeline**:
  - First created in **2010**, during the **House Listing and Housing Census (HLO)** phase of the **2011 Census**.
  - **Updated in 2015–16**.
- **Coverage**:
  - Contains **household-wise data** of approximately **119 crore usual residents**.
- **Data Access**:
  - **Unlike Census data**, which is only released in **aggregate**, **NPR data** can be **shared with Central/State governments and agencies** at the **individual or household level**.

NPR vs Assam NRC

- **Purpose:**
  - **NPR:** Records all usual **residents** for administrative planning.
  - **Assam NRC:** Identifies **genuine Indian** citizens and detects **illegal immigrants** in Assam.
- **Legal Basis:**
  - **NPR:** Citizenship Rules, 2003 (under Citizenship Act, 1955).
  - **NRC (Assam):** Assam Accord (1985) + Citizenship Act; Supreme Court-monitored.
- **Scope:**
  - **NPR: Nationwide.**
  - **NRC: Assam-specific.**
- **Citizenship Link:**
  - **NPR:** Not linked to citizenship status.
  - **NRC:** Directly impacts citizenship; based on documents proving presence **before March 24, 1971.**
- **Data & Outcome:**
  - **NPR:** Demographic database; no exclusion list.
  - **NRC:** Proof-based inclusion; **1.9 million excluded** in 2019 list.

Background on Census Delay

- The **previous Census (2021)** was **postponed due to COVID-19**.
- Now rescheduled to be **completed in 2027**.
- A **pre-test for the 2021 Census** was conducted in **2019**, covering **over 26 lakh people**.

NPR Questionnaire (2019 Pre-Test)

Included questions on:

- Date & place of birth of father and mother
- Last place of residence
- Mother tongue
- Aadhaar number (optional)
- Voter ID
- Mobile phone number
- Driving license number

Census VS National Population Register (NPR):

Aspect	Census	National Population Register (NPR)
Objective & Scope	Comprehensive count of the entire population for demographic, social, and economic profiling.	Database of "usual residents" for administrative and governance purposes.
Legal Basis	Census Act, 1948	Citizenship (Registration of Citizens and Issue of National Identity Cards) Rules, 2003
Data Collected	Detailed demographic, social, and economic data (age, sex, education, etc.)	Basic demographic details; may include biometric data (fingerprints, iris scans).
Purpose	Statistical planning, policy-making, and resource allocation	Targeted welfare schemes, service delivery, and potentially national identity use.
Confidentiality	Data is anonymized; only aggregate data is released.	Individual data is accessible to government agencies; privacy concerns exist.

PRACTICE QUESTION

Q1. Consider the following statements regarding Census and the National Population Register (NPR):

1. Census is conducted under the Citizenship Rules, 2003, while NPR is governed by the Census Act, 1948.
2. Census collects detailed demographic and economic data; NPR collects basic demographic and biometric details.
3. Census data is anonymized; NPR data can be accessed by government agencies.

Which of the above statements is/are correct?

(a) 2 and 3 only

(b) 1 and 2 only

(c) 1 and 3 only

(d) 1, 2 and 3

NAMIBIA TO ROLL OUT UPI

Backdrop: Namibia to adopt UPI digital payment system

Relevance: GS 2/ International Relations

India, Africa must work side by side, says PM in Namibia

India seeks to cooperate, not compete, with Africa, says Mr. Modi; he also congratulated Namibia for adopting UPI digital payment system; Modi given the country's highest civilian honour

Kallol Bhattacherjee
NEW DELHI

Continuing his diplomacy focused on the Global South, Prime Minister Narendra Modi on Wednesday highlighted India's support to Namibia's decolonisation, "not just in words, but in action".

Addressing a special session of the Namibian Parliament, Mr. Modi congratulated the African nation for adopting India's UPI digital payment system. The Prime Minister also highlighted the country's wider Africa policy, emphasising that India does not aspire to "compete" with anyone in the African continent, but rather seeks to "build together".

"India is proud to have stood with Namibia – not just in words, but in action. Like the tough and elegant plants of Namibia, our friendship has stood the test of time. And, just like your national plant *Welwitschia mirabilis*, it only grows stronger with age and time," Mr. Modi told the joint session of the Parliament of Namibia, highlighting the historic support that India extended to Namibia's freedom from the 1940s. According to the records of the Ministry of External Affairs, India was among the first countries to raise the cause of Namibia's independence at the United Nations in 1946.

Close links: Prime Minister Narendra Modi with Namibia President Netumbo Nandi-Ndaitwah in Windhoek. SPECIAL ARRANGEMENT

Africa must lead

Africa should not just be a source of raw materials and minerals, but should "lead in value creation and sustainable growth", the Prime Minister said.

"With Africa, we seek not to compete, but to cooperate. Our goal is to build together. Not to take, but to grow together," he added.

Mr. Modi met with Namibian President Netumbo Nandi-Ndaitwah and signed several agreements, including MoUs to set up an Entrepreneurship Development Centre in Namibia and to cooperate in the field of health and medicine.

Namibia also completed the formalities to join the India-led Coalition of Disaster Resilient Infrastructure and the Global Biofuel Alliance.

The launch of a digital payments system in Namibia later this year was also announced as an outcome of the UPI technology licensing agreement signed between the National Payments Corporation of India and the Bank of Namibia in April 2024.

Mr. Nandi-Ndaitwah also conferred Mr. Modi with the Order of the Most Ancient Welwitschia Mirabilis, Namibia's highest civilian award.

Earlier, Mr. Modi paid homage to the hero of Namibia's freedom movement Sam Nujoma, describing him as "a great friend of India". He recollected Dr. Nujoma's role during the establishment of diplomatic relations between India and Namibia in 1986.

The first diplomatic mission of the South West Africa People's Organisation (SWAPO) was established in India, which provided the organisation with material support as it led the efforts for the liberation of Namibia. India's support to SWAPO is remembered fondly, the Prime Minister said.

About the news

- PM Modi visited Namibia on the final leg of his **five-nation tour**.
- This was **his first visit** to Namibia and the **third-ever by an Indian Prime Minister**.
- Addressed a **special session of the Namibian Parliament**.
- Paid tribute to **Namibia's founding leader Sam Nujoma**, calling him a great friend of India.
- Modi was **conferred Namibia's highest civilian honour**.

Adoption of UPI in Namibia

- Namibia will roll out the **Unified Payments Interface (UPI)**-based **digital payment system later in 2025**.
- PM **Modi congratulated Namibia** during his **address to the Namibian Parliament** for becoming the **first African nation** to adopt **India's UPI system**.
- Part of broader cooperation in **digital technology, defence, healthcare, education, agriculture**, and **critical minerals**.
- The adoption follows a **technology licensing agreement** signed in **April 2024** between:
  - **National Payments Corporation of India (NPCI)**
  - **Bank of Namibia**
- **Strategic Significance**:
  - Marks a key step in expanding **India's digital public infrastructure diplomacy**.
  - Reflects **India-Africa cooperation** in **digital technology and fintech innovation**.

Historic Ties & Decolonisation Support

- India supported Namibia's **freedom struggle from the 1940s**.
- The first diplomatic mission of **SWAPO (South West Africa People's Organization)** was opened in India, which provided **material support**.
- India was **one of the first countries to raise Namibia's independence issue at the UN (1946)**.

Key Themes in PM Modi's Address

- India believes in **cooperation, not competition** with Africa.
- Emphasised **joint development**, sustainable growth, and value creation.
- Urged that **Africa should lead** in global development, not just supply raw materials.
- Referred to Namibia's national plant **Welwitschia mirabilis** as a symbol of enduring Indo-Namibian friendship.

Agreements and Outcomes

- **4 major agreements** signed:
  - **Entrepreneurship Development Centre** in Namibia
  - **Health and Medicine cooperation**
  - Namibia joins **Coalition for Disaster Resilient Infrastructure (CDRI)**
  - Namibia joins **Global Biofuel Alliance**

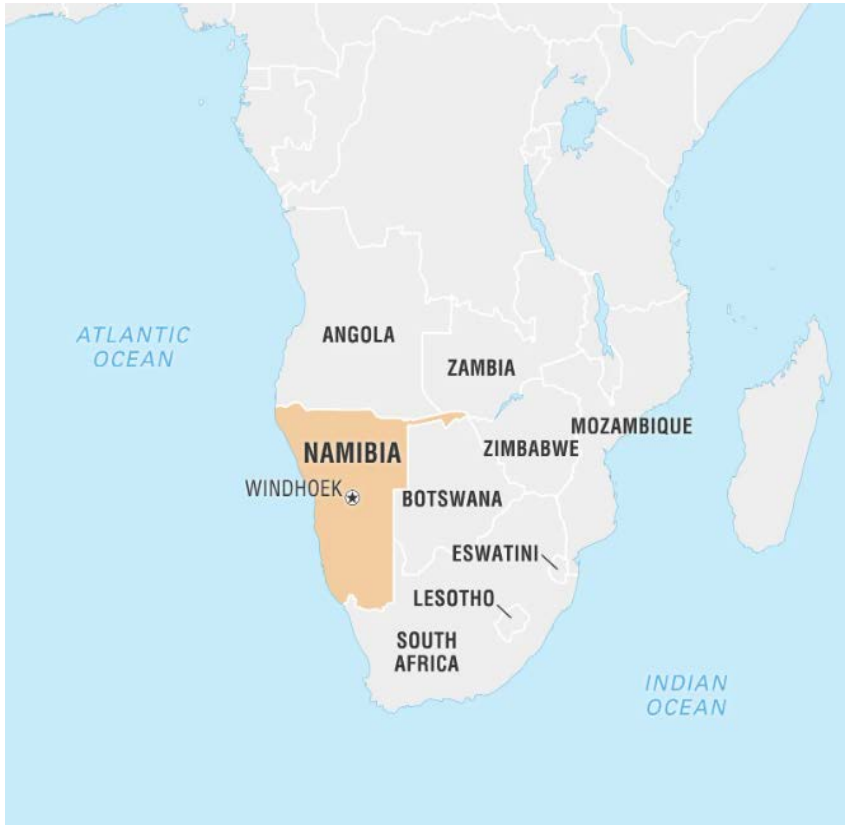
Other Areas of Bilateral Focus

- Strengthening cooperation in:
  - **Digital technology**
  - **Defence and security**
  - **Agriculture**
  - **Healthcare**
  - **Education**
  - **Critical minerals**
  - **Trade, energy, and petrochemicals**

Mapping Corner

Bordering Countries of Namibia

Angola and Zambia to the north, Botswana to the east, and South Africa to the south and southeast. To the west, Namibia's border is the Atlantic Ocean. While Zimbabwe is very close to Namibia's border, they do not share a land border.



PRACTICE QUESTION

Q2. How many of the following countries share a land border with Namibia?

1. Angola
2. Zambia
3. Zimbabwe
4. South Africa

Select the correct answer using the code given below:

(a) Only one

(b) Only two

(c) Only three

(d) All four

CAT BONDS

How can cat bonds plan for a natural disaster?

How do catastrophe bonds operate? Who issues and sponsors them? Why should a financial investor add catastrophe risk to their portfolio? Can cat bonds offer financial relief during extreme weather events? Could India be a lead sponsor for a South Asian cat bond?

EXPLAINER

Safi Ahsan Rizvi

The story so far:

While life insurance is a ubiquitous term in India, disaster risk insurance is not. A low penetration of disaster risk insurance for individual property and livelihoods leaves much of the population exposed to irretrievable damage and loss. Most peoples' assets and means of income remain largely uninsured. Globally, after the hurricanes of the late-1990s in the U.S., when even re-insurers suffered losses, catastrophe risk was farmed out to financial markets through catastrophe bonds (cat bonds).

What is a cat bond?

Cat bonds are a unique hybrid insurance-cum-debt financial product that transforms insurance cover into a tradable security. These bonds transfer hazard risk from the at-risk state to not just the limited stock of global re-insurers, but to deep-pocketed global financial markets through securitisation, opening up a much larger quantum of funds for post-disaster relief and reconstruction. Cat bonds are effective in transferring pre-defined risk to bond investors, ensuring quicker payouts and a much-reduced counter-party risk.

Players that create cat bonds are sovereign nations, which sponsor the bond and pay the premium, with the principal being the sum insured. The sponsor requires an intermediary to issue the bond to reduce counter-party risk. Intermediaries can include the World Bank, the Asian Development Bank or a reinsurance company. If a disaster does occur, the investor runs the risk of losing a part of the principal – a key reason for higher coupon rates of such bonds, compared to regular debt instruments. There is much variation in coupon rates for a cat bond depending on the risks – earthquakes garner lower premiums, as low as 1-2%, compared to hurricanes or cyclones.

GETTY IMAGES

Are cat bonds profitable?

Nobel Prize-winner Harry Markowitz had famously stated that risk diversification is "truly the only free lunch in finance". Risk-seeking investors find the disaster risk curve most attractive for diversification, since climate or geological hazards are historically not related to financial market movements, being mutually exclusive and independent of the financial risk curve. Probabilistic and deterministic financial risk curves move differently from cat-risk curves, in effect de-risking the entire portfolio of an investor. Leading the pack of cat bond investors are pension funds, with a minority share being occupied by hedge funds and family offices, seeking to de-risk their market-centric risk profiles for sovereign-sponsored cat bonds.

Observers assess that since the onset of cat bonds, there have been $180 billion worth new issuances of cat bonds globally with about $50 billion currently outstanding.

Does India need a cat bond?

In these times of climate change, disaster risk can become unprofitable for insurers and re-insurers, as is increasingly evident in the U.S. with the rising intensity of hurricanes and forest fires. This causes premiums to rise and demand to fall, leading to risk ratcheting back to the harried victim of disasters. This is where governments can step-in, sponsoring instruments like cat bonds. The unpredictability and increase in frequency of extreme weather events like cyclones, floods, forest fires and devastating earthquakes in South Asia have increased India's exposure to disaster-risk. India needs to ring-fence its public finances for post-disaster reconstruction. Given the credit standing of the Indian sovereign and the scale of India's hazard risk profile, it could be cost-effective to sponsor such an instrument, through an intermediary like the World Bank, utilising its established bond curves. Apart from assessing the existing risk curve, insurance companies typically build clauses requiring disaster mitigation into contracts with countries, in the absence of which coupon rates rise. On that count, the Indian government is far ahead, having already demonstrated pro-active risk reduction by allocating mitigation and capacity building funds worth $1.8 billion per annum since FY21-22.

Given India's size and financial stability, India could be lead-sponsor for a South Asian cat bond, given that most such regional risks remain unhedged. In addition, the regional hazard matrix reveals an interesting variety of hazards, each with their own risk curve and a different flavour of history, vulnerability, and exposure. Imagine a regional cat bond for high-impact hazards like an earthquake in Bhutan, Nepal and India; or for a supra-cyclone or tsunami in India, Bangladesh, Maldives, Myanmar and Sri Lanka. A South Asian cat bond would spread risk, reduce premium costs and over time, make the region financially stronger to face disasters.

What are the disadvantages?

A defectively designed cat bond could lead to no payout despite a significant disaster. For example, an earthquake cat bond designed for a magnitude threshold of 6.6M for a certain grid may fail if a 6.5M event occurs and causes extensive damage. In addition, despite a contract if a disaster doesn't occur, it could lead to questions on the desirability of such expense. Hence, comparison of premium to be paid discovered through transparent government procedure, with historical annual costs of post-disaster reconstruction could be the best way forward.

Safi Ahsan Rizvi is an IPS officer and adviser to the NDMA.

THE GIST

- Cat bonds are a unique hybrid insurance-cum-debt financial product that transforms insurance cover into a tradable security.
- In these times of climate change, disaster risk can become unprofitable for insurers and re-insurers, as is increasingly evident in the U.S. with hurricanes and forest fires. This causes premiums to rise and demand to fall, leading to risk ratcheting back to the harried victim of disasters. This is where governments can step-in, sponsoring instruments like cat bonds.
- A defectively designed cat bond could lead to no payout despite a significant disaster.

Backdrop: Low penetration of disaster risk insurance for individual property and livelihoods

Relevance: GS 3/Disaster Management

About the news

While life insurance is widely known in India, disaster risk insurance remains uncommon. This leads to low insurance coverage for individual property and livelihoods, leaving people vulnerable to significant, often unrecoverable losses. In this context, **catastrophe bonds (cat bonds)** can be used as they shift risk to financial markets.

What are Catastrophe Bonds (Cat Bonds)?

Cat bonds are a unique **hybrid insurance-cum-debt** financial product that transforms insurance cover into a tradable security.

- They **transfer hazard risk** from the state to **global reinsurers** and **global financial markets** through securitisation.

Securitisation is the process of converting illiquid assets (like loans or insurance risk) into tradable financial instruments (securities), which can then be sold to investors.

- **Structure**:
    - **Sponsor**: Usually a **sovereign nation** that pays the premium, with the principal being the sum insured.
    - **Intermediaries**: They **issue the bond** to reduce counterparty risk. Intermediaries can include the **WB, the Asian Development Bank,** or a reinsurance company.
- **Investor Risk**: If a disaster does occur, the investor runs the risk of losing a part of the principal.
- **Returns**:
    - Offer **higher coupon rates** on such bonds, compared to regular debt instruments.
    - **Premiums vary by disaster type** — e.g., **earthquakes (1–2%)** have lower premiums than **hurricanes or cyclones**.
- **Impact**: Cat bonds help in the **quick mobilization of disaster funds**, especially for countries with **limited fiscal space**.

Are Cat Bonds Profitable?

- **Diversification Advantage**: Cat bonds offer **risk diversification** as **disaster risks** (e.g., earthquakes, hurricanes) are **independent of financial market risks**, making them attractive for investors.
- **Portfolio Benefit**: Including cat bonds helps **de-risk an investor's overall portfolio**, as they **move differently from traditional financial instruments**.
- **Market Size**: Since inception, there have been **$180 billion** worth of **new issuances** of cat bonds globally, with about **$50 billion** currently outstanding

Does India need a cat bond?

- **Climate change has made disaster risk costly** for insurers, raising premiums and lowering coverage. Governments can bridge this gap by sponsoring cat bonds.
- **Government** can **sponsor cat bonds** to shift risk to global financial markets and **protect public finances** for post-disaster reconstruction.
    - **Feasibility**:
        - India has a strong **sovereign credit profile** and could issue cat bonds **cost-effectively** through intermediaries like **World Bank**.
        - The government already allocates **$1.8 billion annually** for disaster mitigation and capacity-building (since FY21-22).
- **Regional Potential**:
    - India could be the **lead sponsor** of a **South Asian cat bond**, sharing risk across countries like **Nepal, Bhutan, Bangladesh, Sri Lanka, the Maldives, and Myanmar**.
    - A **regional cat bond** would **diversify hazard risk**, lower premiums, and build **regional financial resilience**.

What are the disadvantages?

- **Trigger Risk**: If poorly designed, a cat bond may **not pay out even after a major disaster**.
    - E.g., An Earthquake cat bond designed for a magnitude threshold of 6.6M may fail if a 6.5M event occurs and causes extensive damage.
- **No Disaster, No Payout**: If **no disaster occurs**, the **premium paid is lost**.
- **Design Complexity**: Accurate **calibration of risk triggers** is essential to avoid mismatch between the event and coverage.
- **Cost-Benefit Concerns**: Justifying the **premium expense** requires **transparent government processes** and comparison with **historic post-disaster spending** to assess value.

PRACTICE QUESTION

Q3. With reference to Catastrophe Bonds (Cat Bonds), consider the following statements:

1. Cat bonds are tradable financial instruments that combine features of insurance and debt.
2. These bonds transfer disaster risk from sovereign states to global reinsurers and financial markets.
3. The Government of India currently uses cat bonds to finance post-disaster reconstruction.
4. Investors in cat bonds do not face any risk of losing their principal.

Which of the statements given above are correct?

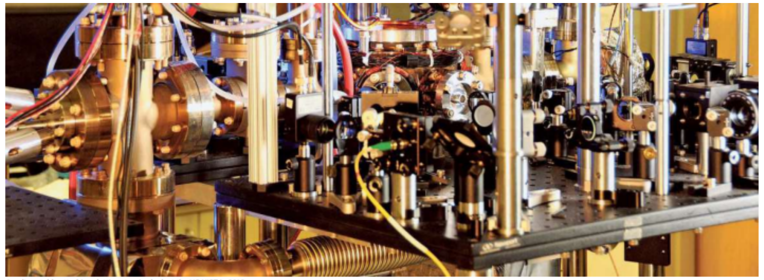
(a) 1 and 2 only

(b) 2 and 3 only

(c) 1,2 and 3 only

(d) 1, 2 and 4 only

REDEFINING THE SECOND



An ultra-stable ytterbium lattice atomic clock at the US NIST in 2013. PUBLIC DOMAIN

Intercontinental clock comparison sets stage to redefine the second

Because they can enumerate one second up to 18 decimal places, scientists expect optical clocks will become the world's new time standard around 2030. Until then, however, optical clocks will have to pass rigorous tests attesting to their ability to work in step from different parts of the world

Vasudevan Mukunth

Researchers from around the world have completed the world's largest, most demanding head-to-head comparison of clocks in history to build confidence for the upcoming redefinition of the second.

The duration of a single second is currently defined by caesium (Cs) atomic clocks. Lasers "count" the radiation emitted by Cs atoms in these devices to measure one second, give or take a few

navigation, climate science, and radio astronomy – expectations of their performance have also increased, necessitating the more advanced optical clocks.

Scientists around the world have been studying and testing these next-generation devices. Because they can enumerate one second up to around 18 decimal places, scientists expect optical clocks will replace Cs atomic clocks as the world's new time standard around 2030. Until then, however, optical clocks will have to pass rigorous tests attesting to their ability to work in step from different parts of the world.

The new effort presents the largest, most sophisticated such test to date. It involved 10 optical atomic clocks on three continents and 65 researchers.

SI unit of time

To measure the passage of time, strike up a conversation with the person next to you. If it's riveting, time will fly. But if it advances in painstaking steps, time will slow to a crawl.

For better or for worse, this isn't good enough for scientists. To understand how much time one second denotes, they use natural phenomena. In the early 20th century, the definition of a second was one-86,400th of a mean solar day. The first quartz crystal clocks that appeared in the late 1940s could measure time more accurately than the earth's rotation. So scientists switched to the earth's revolution around the sun. In 1956, one second became equal to one-31,556,925.9747th of the time the earth took to go once around the sun from January 0, 1900.

Since then, scientists have been building better clocks that, at each step, also incentivised them to refine the time standard. The current standard is based on atomic clocks. These clocks don't directly measure time. Instead, they are complicated setups scientists put together to generate radiation of a fixed frequency. (Frequency is nothing but the inverse of time.)

In 1967, the SI unit of time was defined thus: "the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom". This verbose definition really communicates a simple meaning.

Pass the last one

An atom's internal energy comes in fixed steps, like rungs on a ladder. It can jump up a rung by absorbing the right amount of energy and jump back down by giving that energy up again.

In a Cs atomic clock, the energy that makes the jump is supplied by a finely tuned microwave signal. The atoms react

watch how many atoms make the jump. If that number slips below a peak, the equipment nudges the microwave setting until the jump rate is back to the maximum. When that happens, the microwave signal itself is guaranteed to be exactly 9,192,631,770 Hz, i.e. composed of 9,192,631,770 waves per second.

Chips called frequency dividers count these microwave waves and pass on only every 9,192,631,770-th one. This wave comes along every one second – and is the SI definition of the second.

Around the world, many countries have set up their own Cs atomic clocks to define their respective national time standard. In India, the National Physical Laboratory in New Delhi maintains five Cs atomic clocks. The clocks' output is disseminated to various applications around India via the INSAT satellites, telecommunication signals, and fibre links. Scientists, however, are already at work refining the next big thing: the optical atomic clock.

Good for 15 billion years

The wall clock hanging in your house is likely powered by two AA batteries and uses a quartz crystal oscillator. After a few months, the clock will start losing a few seconds. The Cs atomic clock that defines the US national time standard loses only one second every 300 million years, however.

This is stupendous, yet in some cases it isn't good enough. As their application in defining the time standard suggests, atomic clocks are used in many technologies that we encounter every day. The American GPS network, Russia's GLONASS, Europe's Galileo, and India's NavIC constellation use atomic clocks onboard satellites to accurately measure distance and location data for both civilian and military use. Astronomers use it in radio-astronomy to piece together signals received on different parts of a large telescope. This is how they captured history's first photograph of a black hole in 2019. Climate scientists use atomic clocks for ultra-precise measurements of the earth's gravity that reveal where ice and water have been lost.

As these applications have expanded,

In India, the National Physical Laboratory maintains five Cs atomic clocks. Their output is disseminated around India via satellites, telecommunication signals, and fibre links

the expectations of atomic clocks have, too. The definitive emission in Cs atomic clocks, of 9,192,631,770 Hz, is in the microwave range of the electromagnetic spectrum. In optical atomic clocks, it's in the optical (or visual) range. The radiation

429,228,066,418,009 Hz. When a ytterbium-ion jumps between two levels, the radiation has frequency 642,121,496,772,645 Hz. Because this radiation contains 10,000-times more waves per second, a device that can count them out can also measure one second more precisely.

The frequency of the radiation emitted is also proportional to the clock's stability. In 2014, one optical atomic clock that used strontium atoms would reportedly drift by less than one second in 15 billion years. This is why optical atomic clocks are set to become the next global time standard.

But ahead of the milestone, scientists must prove that clocks in different countries agree with one another to the 18th decimal place.

Across three continents

Enter: the new test. It involved 10 optical clocks based on five atoms: strontium-87 (Sr), ytterbium-171 (Yb), charged ytterbium-171 ions in two states (Yb^+ E2 and Yb^+ E3), charged strontium-88 (Sr^+), and indium-115 ions (In^+). The clocks were located at six national metrology institutes in Finland, France, Germany, Italy, the U.K., and Japan.

The two clocks participating from Germany were in the same building, so the scientists linked their outputs through short optical fibres. The clocks across France, Germany, and Italy were linked with telecommunication fibres that already run through these countries. To prevent any noise or distortion from corrupting the data, scientists installed bespoke repeaters and amplifiers. Finally, to link the clocks across the English Channel, the Baltic Sea, and all the way to Japan, the teams used an advanced GPS technique called integer precise point positioning (IPPP).

Because optical clocks occasionally take breaks for maintenance, the teams set up simpler backup clocks that stepped in temporarily to keep time using GPS data. When the optical atomic clocks were back in operation, the backups would handover and step back.

In this way, all the clocks ran for 45 days between February 20 and April 6, 2022. Every time two different clocks were running and connected, the researchers divided their laser frequencies to make a ratio. In total the teams reported 38 independent optical-frequency ratios, far more than any earlier project. Four of these ratios – Yb^+(E3) to Yb, In^+ to Yb, Sr^+ to Sr, and Sr^+ to Yb – had never before been measured directly. The tightest single result was the ratio between the In^+ and Yb^+(E3) clocks in Germany, measured locally with an uncertainty of just 4.4×10^{-18}.

The teams found that the fibre and satellite links told the same story for most

of less than 2×10^{-16} via both technologies, showing that long fibres and IPPP could both support ultra-precise timing in good conditions. Similarly, same-atom ratios – Sr to Sr, Yb to Yb, and Yb^+ to Yb^+ – confirmed that many clocks were healthy. The Germany and the U.K. clocks were compared by GPS across the North Sea and matched within 3×10^{-16} even after accounting for downtime.

Combine results responsibly

The researchers were also able to reveal gaps they will have to fix before 2030. Every GPS-based ratio that involved the Italian Yb clock was off by about 4×10^{-15} compared with fibre measurements, pointing to a previously unnoticed signal distribution glitch at the Italian facility. The strontium clocks in France and Germany showed small but real offsets, up to 2×10^{-16}, when the teams checked them against other clocks and each other. These shifts were large enough to matter for a future definition of the second and will need further study.

The authors of the paper describing the test, published in *Optica* on June 12, noted that recognising such hiccups is exactly why large, redundant campaigns are valuable.

Because many ratios shared the same clocks, fibres, backups or GPS receivers, the teams noted that their errors were correlated. To address this, they developed a 38 × 38 matrix capturing 242 non-zero correlation coefficients. These coefficients captured the degree to which any two variables were related, e.g. it was 0.94 when two ratios shared a common clock on the same fibre. The teams said publishing these correlations will allow future analysts combine results responsibly instead of double-counting information.

In the final analysis, by showing that 10 heterogenous clocks across three continents could agree with each other to within a factor 10^{-16} to 10^{-18}, and by identifying the rare cases when they didn't, the test has cleared many obstacles *en route* to redefining the SI second with optical atomic clock standards.

(mukunth.v@thehindu.co.in)

Backdrop: Optical clocks will become the world's new time standard around 2030

Relevance: GS3 - Science and Tech

About the news

Researchers worldwide conducted the **largest and most demanding clock comparison** to prepare for the **redefinition of the second**.

This involved **10 optical clocks across 3 continents** and **65 researchers** in the most sophisticated test to date.

Need to Redefine the Second

- **High Precision:** Must measure time accurately up to **18 decimal places**.
- **Limitations of Cs Clocks:** Current Cs-based definition insufficient for modern applications like GPS and climate science.
- **Future Transition:** Optical clocks expected to replace Cs clocks by **2030**, pending validation.

Evolution of the SI Unit of Time

- **Early 20th century**: 1 second = 1/86,400 of a mean solar day.
- **1956**: Redefined as 1/31,556,925.9747 of a tropical year.
- **1967 (Current definition)**: 1 second = **9,192,631,770 periods of the radiation corresponding to** transition between the two hyperfine levels of the ground state of the caesium-133 atom

India’s Timekeeping System

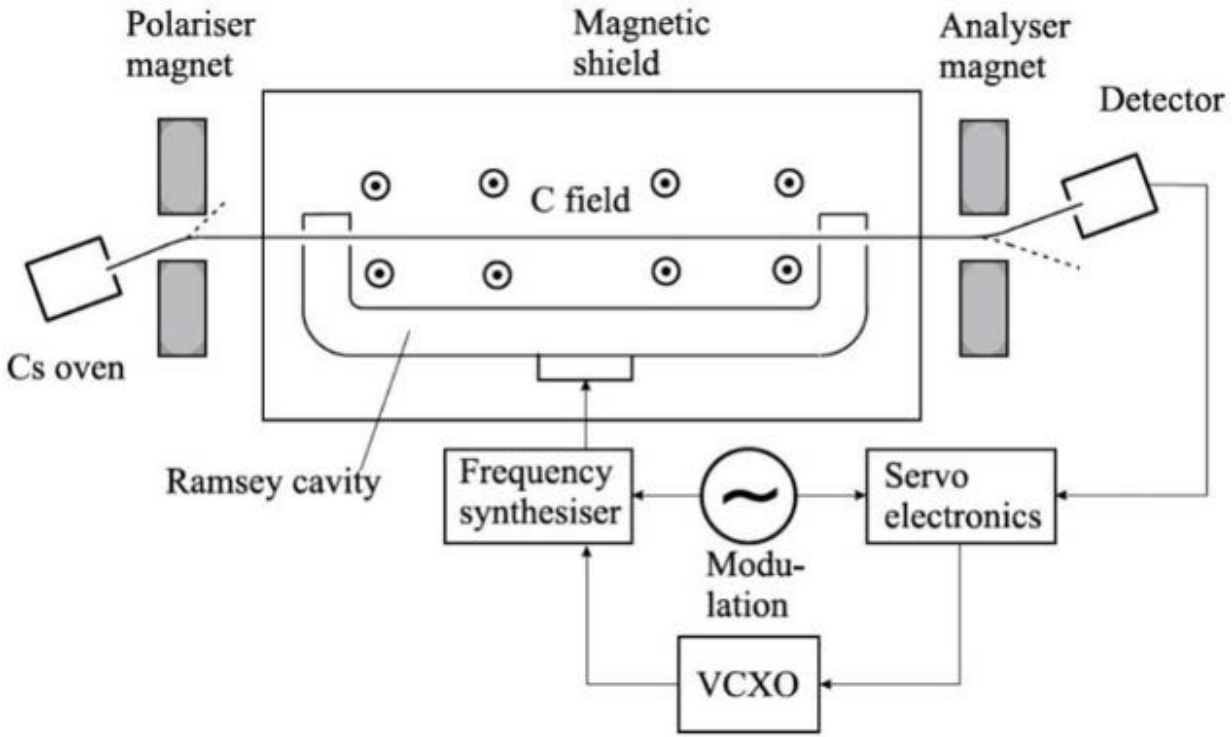
- Maintained by the **National Physical Laboratory (NPL), New Delhi**.
- India operates **five Cs atomic clocks**.
- Output disseminated through **INSAT satellites**, **telecom signals**, and **fibre-optic links**.

Current Standard: Caesium Atomic Clocks

- The **second** is currently defined using **Caesium (Cs) atomic clocks**.
- These clocks measure time by **counting 9,192,631,770 microwave radiation cycles** emitted by Cs-133 atoms.
- Atomic clocks don't directly measure time, but rely on generating **radiation at fixed frequencies**.
- **Time = Inverse of Frequency**, making frequency the core metric for timekeeping.

Working of a Caesium Atomic Clock

- Atoms have **fixed energy levels** like rungs of a ladder.
- Cs atoms absorb energy via finely tuned **microwave signals** to jump energy levels.
- Maximum reaction occurs at **exactly 9,192,631,770 Hz**.
- **Frequency dividers** count and pass every 9,192,631,770th wave to define one second.



Rising Demands & Limitations of Cs Clocks

- Atomic clocks now support critical systems:
  - GPS (USA), GLONASS (Russia), Galileo (EU), NavIC (India).
  - **Radio astronomy** – e.g., imaging the first black hole (2019).
  - **Climate science** – tracking gravity changes due to water/ice loss.
- **Cs atomic clocks** drift ~1 second in **300 million years** — impressive, but not sufficient for some modern needs.

Optical Atomic Clocks – The Future

- Optical clocks use **light (optical) frequencies** instead of microwaves.
- Frequencies used:
  - Strontium: **429,228,066,418,009 Hz**
  - Ytterbium ion: **642,121,496,772,645 Hz**
- Higher frequency = **greater precision and stability**.
- A **2014 strontium optical clock** would drift <1 second in **15 billion years**.
- Expected to **replace Cs clocks as the global standard by 2030**.

Challenges Before Redefinition

- Optical clocks must **synchronize accurately worldwide**, up to the **18th decimal place**.
- Requires **rigorous, coordinated global tests**.

Global Optical Clock Comparison Test (2022)

Test Overview

- 10 optical clocks tested.
- Used 5 atoms:
  - Sr-87, Yb-171, Yb^+ (E2 & E3), Sr^+-88, In^+-115.
- Clocks housed at 6 metrology institutes:
  - Finland, France, Germany, Italy, U.K., Japan.

Key Findings

- **Best result**: In^+ and Yb^+(E3) clocks in Germany — **uncertainty of 4.4×10^{-18}**.
- **Sr clocks** in Germany and France differed by **$<2 \times 10^{-16}$**, validating both **fibre and IPPP** links.
- Same-atom comparisons (Sr–Sr, Yb–Yb, Yb^+–Yb^+) showed good clock health.
- U.K.–Germany clocks matched within **3×10^{-16}**, even with downtime.

Identified Gaps and Issues

- **Italian Yb clock** showed **~4 × 10^{-16}** discrepancy (GPS vs fibre) → signal glitch.
- France–Germany **Sr clocks** had small but **significant offsets** (up to **2 × 10^{-16}**) needing further analysis.
- Many frequency ratios shared **common hardware** (clocks, fibres, receivers), leading to **correlated errors**.
- A **38 × 38 matrix** captured **242 correlation coefficients**.
    - e.g., correlation of **0.94** when two ratios shared a clock on the same fibre.
- Publishing this data prevents **double-counting** in future analyses.

Final Outcome

- 10 optical clocks across 3 continents agreed within **10^{-16} to 10^{-18}**.
- The study cleared **key hurdles** toward **redefining the SI second** with optical clocks by ~2030.

PRACTICE QUESTION

Q4. With reference to atomic clocks and the SI unit of time, consider the following statements:

1. The current definition of a second is based on the microwave frequency emitted by Caesium-133 atoms.
2. Optical atomic clocks offer higher precision than Caesium clocks due to their use of higher frequencies.
3. Atomic clocks infer time by measuring radiation frequency, not by directly counting time.

Which of the statements given above is/are correct?

(a) 1 and 2 only

(b) 2 and 3 only

(c) 1 and 3 only

(d) 1, 2 and 3

MEASURING INEQUALITY

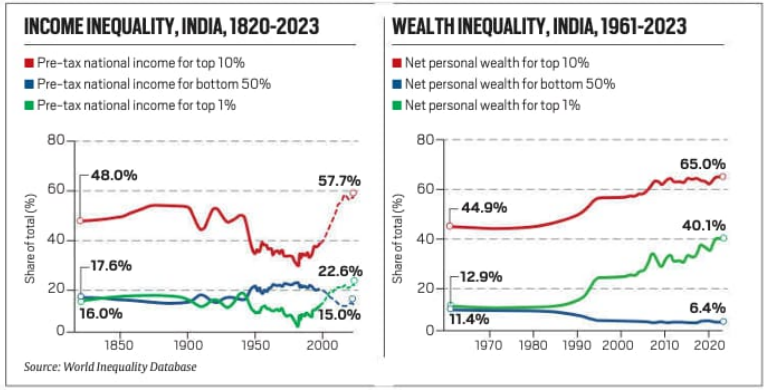
Backdrop: Release of World Bank's latest Poverty and Equity Brief

Relevance: GS 3/Inclusive Growth and issues arising from it

Measuring inequality

Referring to a World Bank brief, the government has claimed India is world's 'fourth most equal country'. What does this conclusion miss? What are pitfalls of relying solely on consumption-based Gini Index?

UDIT MISRA



A GOVERNMENT release over the weekend claimed that "India is not only the world's fourth largest economy, it is also one of the most equal societies today". Using data from the World Bank's latest Poverty and Equity Brief, it said India's Gini Index was at 25.5, which made it the world's "fourth most equal country…after the Slovak Republic, Slovenia and Belarus", reflecting how fruits of economic progress were being shared "more evenly across its population".

The Gini Index or Gini coefficient, named after the early 20th century Italian statistician Corrado Gini, has historically been the most commonly used measure of inequality. It measures inequality on a scale from 0 to 1 (or 0% to 100%), with higher values indicating higher inequality.

The government's claim has been contested both by academics who study inequality, as well as observers who see India as a country with high and rising inequality.

An incomplete picture

The paragraph in the World Bank's *Poverty and Equity Brief* referenced by the government includes important qualifiers that the release did not mention:

"India's consumption-based Gini index improved from 28.8 in 2011-12 to 25.5 in 2022-23, though inequality may be underestimated due to data limitations… The World Inequality Database shows income inequality rising from a Gini of 52 in 2004 to 62 in 2023. Wage disparity remains high, with the median earnings of the top 10 percent being 13 times higher than the bottom 10 percent in 2023-24."

The government release does not mention the "data limitations" that the World Bank itself has flagged, and does not take into account the Gini Index value calculated by the World Inequality Database, which shows a rise in the Gini Index from 2004 to 2023.

Consumption-based Gini

To map income inequality, countries often conduct surveys on income data. India, however, collects data on consumption, not income. When it comes to inequality, this makes a big difference because variation in income is far more than variation in consumption. As people earn more, the bulk of their additional income is turned into savings. As such, a Gini Index of inequality using consumption data underestimates the level of inequality in a society.

Also, economists such as Anmol Somanchi, who works at the World Inequality Lab (run by the Paris School of Economics and University of Berkeley, California), have pointed out that it is misleading to compare India's consumption-based Gini Index value with that of other countries, which use an income-based Gini.

In short, the use of consumption-based Gini underestimates inequality and undermines comparability with other countries.

Limitations of survey data

It is widely acknowledged that the gap between the bottom 10% and top 10% of the population is widening, even if it is assumed that everyone in the country is becoming better off.

However, the calculation of inequality is unlikely to capture the widening gap. This is because surveys, whether they are about consumption or income, typically falter in capturing the data of the richest. This is for two broad reasons.

One, the rich exhibit what is technically called a "differential non-response", Somanchi said. In other words, the rich tend to decline to participate in surveys much more than the poor do.

Two, the way the sampling of these surveys works, the chances of the richest persons in the country being drawn in a random sample are pretty low. This becomes a big reason for underestimation of inequality if just a handful of the extremely rich are driving up inequality.

Thus, if 90% of the population is not "unequal" while most of the inequality is being driven by the top 1%, any survey that fails to sample the top 1% will fail to capture the real picture on inequality.

Researchers have flagged this underestimation in several other countries such as the US, the UK, and many other European countries as well.

A way to correct for this lapse in sampling is to use the survey data in conjunction with income tax data, which is uniquely accurate in capturing the incomes of the top earners in a country. Studies that did this in the UK, the US, and elsewhere found that relying solely on survey data underestimated inequality.

The World Inequality Lab Gini Index, which shows that inequality in India has increased, uses income tax data to correct for this gap.

Problems with Gini Index

The Gini Index too does not capture all aspects of the inequality picture. This is because it is not 'sensitive' to changes at the extremes of a population, but is overly sensitive to changes in the middle.

This has to do with the way the Gini Index is calculated — and experts have been urging for close to 50 years now that other measures should be considered. One option is the Palma Ratio, named after a Chilean economist who suggested looking at the shares of income (or wealth) at the extremes — the bottom 50% and the top 10%, for instance.

When such comparisons are calculated with the use of income tax data (apart from survey data), the emerging picture is grim: it shows income inequality is now worse than in the colonial period, and the top 1% earn far more than the bottom 50%.

Bigger picture on inequality

The point of studying inequality is to allow governments to tailor appropriate policies to alleviate excessive inequality. However, an inaccurate reading of inequality can lead to policies that actually exacerbate existing inequalities. If high inequality is not contained, it can create social unrest and eventually militate against sustained economic growth.

Relying solely on the Gini Index, that too with severe data limitations, can obscure the reality. As explained above, a given version of the Gini Index could be falling even when inequality between the two extremes of the population may be rising.

About the news

According to the World Bank's latest **Poverty and Equity Brief,** India's **Gini Index is 25.5,** which makes it the world's **fourth most equal country,** after the Slovak Republic, Slovenia, and Belarus. It reflects how the fruits of economic progress are being shared more evenly across its population. However, this claim has been questioned due to methodological concerns and differing data sources.

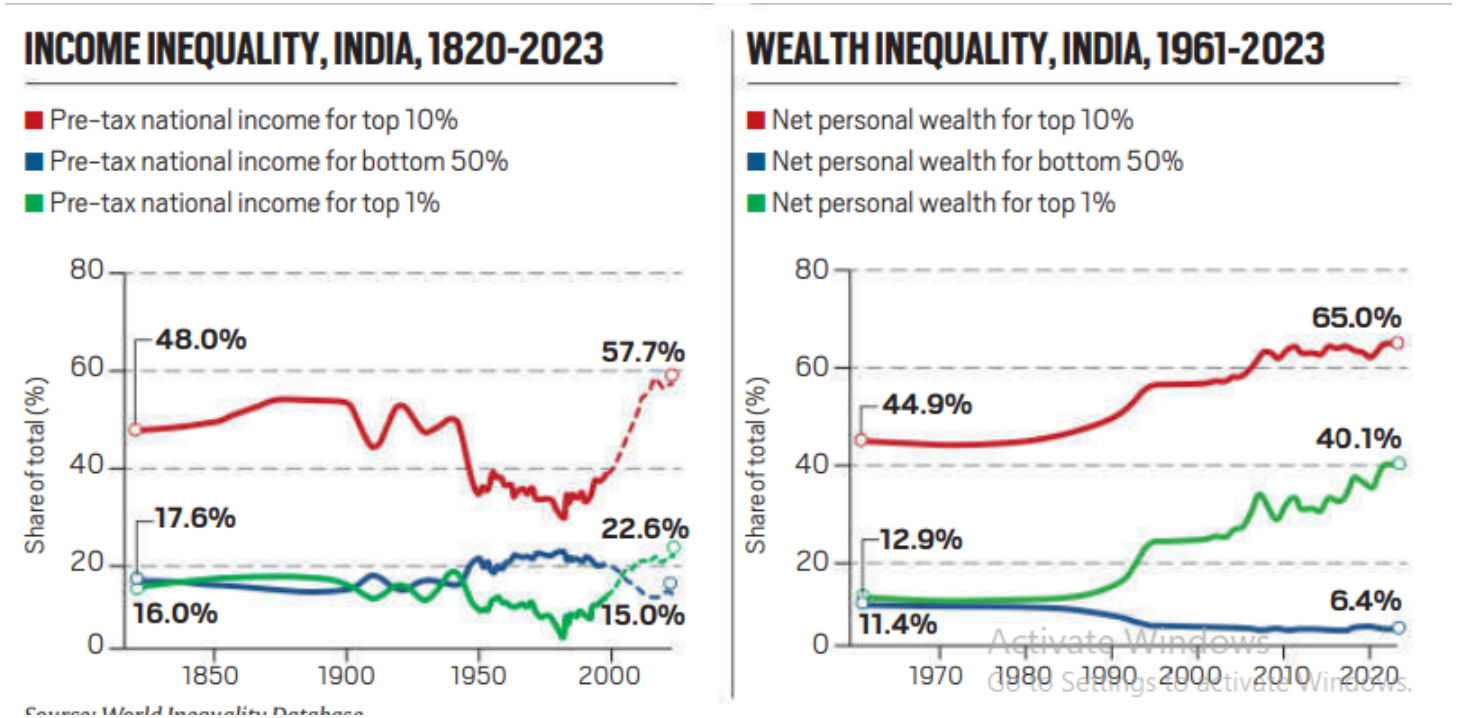
Gini Index (or Gini Coefficient): Measure of **inequality** in income or wealth distribution within a country.

Scale:

- **0 = Perfect equality** (everyone has the same income or wealth).
- **100 = Perfect inequality** (one person has all the income/wealth, others have none).

Key Issues with the Government's Claim

- India's consumption-based Gini index has improved (from 28.8 in 2011-12 to 25.5 in 2022-23); however, inequality may be underestimated **due to data limitations**.
- The **World Inequality Database** shows,
  - **Income inequality** rose from a Gini of 52 in 2004 to 62 in 2023.
  - **Wage disparity remains high:** The **top 10%** earn **13 times** more than the **bottom 10%** (2023-24).



Problems with Measuring Inequality

- **Consumption vs. Income Data**
  - To map income inequality, India collects **data on consumption,** not income (unlike other countries). It underestimates the level of inequality in a society.
  - **Reasons:**
    - The **variation in income is far greater** than the variation in consumption.
    - **Wealthier individuals save more**, and their higher incomes don't reflect in consumption.
- **Limitations of survey data**
  - The calculation of inequality is **unlikely to capture the widening gap** between the bottom 10% and the top 10% of the population.
  - **Reasons:**
    - The rich tend to **decline to participate** in surveys much more than the poor do. It underestimates inequality if just a handful of the extremely rich are driving up inequality.
    - Researchers have flagged this underestimation in countries such as the US, the UK, and many other European countries as well.
- **Problems with the Gini Index**
  - It is not 'sensitive' to changes at the extremes of a population, but is overly sensitive to changes in the middle.

Policy Implications of Inaccurate Inequality Assessment

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- **Problems with the Gini Index**
  - It is not 'sensitive' to changes at the extremes of a population, but is overly sensitive to changes in the middle.

Policy Implications of Inaccurate Inequality Assessment

- **Misallocation of Resources** – Welfare schemes may not reach those most in need.
- **Worsening Inequality** – Flawed policies may benefit the rich, widening the gap.
- **Regressive Fiscal Measures** – Poorly designed taxes and subsidies may favor the affluent.
- **Exclusion of Vulnerable Groups** – Targeted support may miss the poorest.
- **Loss of Public Trust** – Perceived disconnect between data and reality can erode confidence
- **Risk of Social Unrest** – Rising disparities may fuel discontent and instability.
- **Hindered Inclusive Growth** – Skewed planning limits broad-based economic progress.
- **Delayed Reforms** – Structural issues remain unaddressed due to distorted insights.

What can be done?

- **Combine household survey data with income tax records** to more accurately capture top-end incomes and correct the underestimation of inequality.
- **Adopt Alternative Indicators:** Use the **Palma Ratio** alongside the Gini Index to focus on disparities between the **top 10% and bottom 50%**, offering a clearer picture of extreme inequality.
- **Use Multidimensional Measures:** Complement income-based metrics with **education, health, and wealth indicators** to assess inequality more holistically.
- **Encourage Independent Research:** Support academic and institutional studies like those by the **World Inequality Lab** to refine and validate inequality assessments.

Conclusion

To address inequality effectively, it is essential to move beyond limited measures like the consumption-based Gini Index. It will enable more accurate assessments and better-informed, inclusive policy decisions.

PRACTICE QUESTION

Q. **"Overreliance on flawed inequality metrics can distort public policy and undermine inclusive growth." In this context, critically examine the limitations of current inequality measurement and suggest alternative approaches for accurate assessment.** ***(250 words)***