1. Why growth of India's overall green cover is not all good news

Introduction

The 18th biennial State of Forest Report (ISFR-2023) by the Forest Survey of India (FSI) found a marginal gain of 156 sq km in forest cover, and a sizable increase of 1,289 sq km in tree cover since 2021.

For the first time, India's green cover has exceeded the 25% threshold with 8,27,357 sq km (25.17%) of the country now under forest (21.76%) and tree (3.41%) cover. Of this, 4,10,175 sq km is classified as dense forests.

Trees and forests

Tree patches smaller than 1 hectare do not count as forests, and have been measured separately by FSI as tree cover since 2001. The latest biennial cycle registered the sharpest growth in tree cover. From 3.04% in 2003, it had fallen to 2.76% in 2011, before rising to 2.91% in 2021. IFSR-2023 recorded a 0.5 percentage point jump in two years, with tree cover rising to 3.41%.

In comparison, India's forest cover has increased by only 0.05 percentage points since 2021. This is consistent with the trend of diminishing growth since India's forest cover crossed the 20% threshold at the turn of the millennium. Between 2003 and 2013, forest cover increased by 0.61 percentage points, from 20.62% to 21.23%. In the next 10 years, it grew by only 0.53 percentage points to 21.76%.

Forests within forest

Irrespective of land use or ownership, tree patches measuring 1 hectare or more with a minimum canopy cover of 10% are counted as forests in India. Areas with a canopy density of 40% and above are considered dense forests, and those with canopy density of 10-40% are open forests (OF). Since 2003, areas with at least 70% canopy density have been classified as very dense forests (VDF).

Depending on factors such as climate and biotic pressure, a forest can improve or degrade to the next density category — a VDF patch may thin to become a moderately dense forest (MDF) or an OF may get upgraded as an MDF — during a 2-year IFSR cycle. When a previously forested area is recorded as non-forest (NF) or shrub (below 10% canopy), it means that the forest has been wiped clean.

Plain aggregated data on the quantum of different forest types do not represent this dynamic process where natural forests transform, disappear, and are replaced by plantations that typically grow much faster. Since 2003, ISFRs have made available data on this "change matrix" which, stitched together, indicates the broad trends over two decades.

Forest balance sheet

ISFR-2023 shows that 3,913 sq km of dense forests — an area larger than Goa — have disappeared in India in just two years since 2021. This is consistent with the worsening trend over the past two decades: 17,500 sq km of dense forests were wiped out between 2013 and 2023, while 7,151 sq km disappeared between 2003 and 2013.

CHANGE IN DENSE FOREST COVER 2003-2023

	2021-23	2003-2013	2013-2023	2003-2023
LOST				
VDF to NF	295	288	1277	1565
MDF to NF	3362	6714	15086	21800
VDF to scrub	24	5	65	70
MDF to scrub	313	144	1153	1297
Disappeared	**3994**	**7151**	**17581**	**24732**
VDF to OF	228	134	1128	1262
MDF to OF	5166	6414	22249	28663
Total loss	**9388**	**13699**	**40958**	**54657**
GAINED				
NF to VDF	56	43	483	526
NF to MDF	839	3631	7554	11185
Scub to VDF	1	0	54	54
Scrub to MDF	102	105	1043	1148
OF to VDF	496	124	2567	2691
Plantations	**1494**	**3903**	**11701**	**15604**
OF to MDF	8610	6122	34301	40423
Total gain	**10104**	**10025**	**46002**	**56027**
NET CHANGE	716	-3674	5044	1370

VDF: Very Dense Forest (canopy over 70%) | **MDF:** Moderate Dense Forest (canopy 40-70%)
OF: Open Forest (canopy 10-40%)| **Shrub** (canopy under 10%) | **NF:** Non-Forest (no canopy)

Source: ISFR 2003-23

Overall, India has witnessed the complete destruction of 24,651 sq km — more than 6.3% — of its dense forests in the two decades since 2003. As a single forest unit, that would be nearly half the size of Punjab.

The bulk of this loss has been offset by the rapid transformation of 15,530 sq km of non-forested or scantly forested land to dense or even very dense forests in successive two-year windows during 2003-2023. These are plantations, say experts, because natural forests do not grow this fast.

ISFR-2023 accounts for 1,420 sq km of plantations becoming dense forests since 2021. This again shows a downhill trend: areas under plantations-as-dense-forests are expanding as the disappearance of dense forests becomes routine.

Better management has helped large swaths of OFs become MDFs in the last decade. At the same time, plantations are supplementing these natural gains to keep the extent of India's dense forest cover stable: the "change matrix" shows an increase of 1,370 sq km over 20 years. Of this, 716 sq km was gained in the 2021-23 cycle alone.

On paper, though, India's dense forest cover has grown by 21,601 sq km — or 6% — during 2003-2023 due to a series of unexplained revisions of data presented in ISFR-2005, -2009, -2015 and -2021, adding a total of 20,232 sq km of dense forest to the inventory.

The implications

Under this opaque veneer of overall stability and growth in forest cover, the trend of steady replacement of natural dense forests with plantations has been criticised by experts.

Plantations usually have trees of the same age (and often the same species), are vulnerable to fire, pests and epidemics, and often act as a barrier to the regeneration of natural forests which are more biodiverse, perform a wider range of ecological functions, and support numerous species.

Old natural forests also stock a lot more carbon in their frame and in the soil. In 2018, the United Nations Framework Convention on Climate Change (UNFCCC) flagged India's assumption that plantations reach the carbon stock level of existing forests in just eight years. Plantations are frequently promoted for their rapid growth which can achieve carbon targets faster. On the flip side, plantations are often harvested more readily, defeating climate goals in the long term.

Relevance: GS Prelims & Mains Paper III; Environment

2. What are India's plans for a quantum satellite?

Introduction

On December 13, Ajai Chowdhry, chairman of the Mission Governing Board of the National Quantum Mission, said India plans to launch a quantum satellite in "2-3 years for quantum communications".

What is the National Quantum Mission?

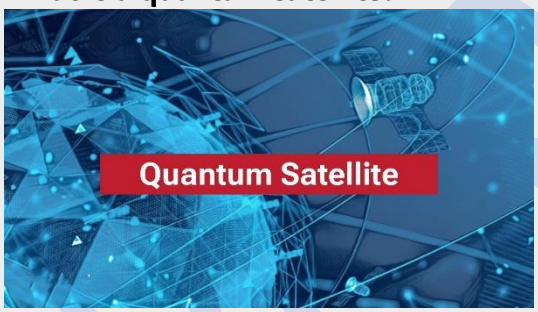
The National Quantum Mission (NQM) is a Department of Science & Technology programme to accelerate the use of quantum physics to develop advanced communications and sensing systems.

The development of computers changed the course of human history from the mid-20th century onwards. Advances in this sector gave humankind satellites, telecommunications, weather forecasts, drug-discovery programmes, etc.

But these advances are reaching a saturation point because the physics phenomena on which they are based, called classical physics, are hitting a performance upper-limit. So scientists around the world are developing new technologies to solve the same problems but using phenomena of quantum physics. Because the rules of quantum physics allow for the outcomes of classical physics as well as new 'bonus' ones, the new devices are expected to be more versatile problem-solvers.

The Union Cabinet approved the NQM in April 2023 at ₹6,000 crore, to be implemented from 2023 to 2031. The planned quantum satellite is part of this package.

What is a quantum satellite?



A quantum satellite is a term for a communications satellite that uses quantum physics to secure its signals.

Communications is a broad term that refers to technologies that send and receive signals. An important part of these technologies is security: preventing bad actors from intercepting a message being transmitted across large distances, through multiple networks.

The advent of quantum computers threatens the technologies currently being used to secure messages. Fortunately, quantum physics has also paved the way for new forms of protection, and quantum satellites are expected to facilitate them.

How are messages secured?

Say two people, Anil and Selvi, are standing at two ends of a playground and wish to speak to each other. They could shout or wave their hands. However, Anil composes his message, encrypts it, and writes the encrypted text on a piece of paper. He ties it to the foot of a messenger pigeon and sends it to Selvi. If Selvi knows how Anil encrypted the message, she can decrypt it to access the original text.

Encryption is the task of concealing information. The manner is called the cipher. A simple example is the Caesar cipher, where the letters of the alphabet are offset by a fixed number. If the number is 5, the words BIRDS FLY AWAY become GNWIX KQD FBFD.

Say there is a third person, Kaushik, standing in the middle of the ground and trying to eavesdrop on the conversation. If he intercepts the pigeon, he can't crack the text unless he knows the manner of encryption.

This security paradigm is called cryptographic security. It works by hiding the secret code, or key, behind an extremely difficult mathematical problem. A bad actor like Kaushik can solve the problem with a powerful computer to reveal the code — but the harder the problem, the more time (and/or more computing resources) he will need.

Even the most powerful supercomputers have difficulty cracking the best Advanced Encryption Standard ciphers in use today — but quantum computers may be able to do better.

How can quantum physics protect messages?
Quantum cryptography uses the tenets of quantum physics to secure messages. Its most famous type is quantum key distribution (QKD).

In the example before, Anil used a key to encrypt his message and Selvi, who knew the key, used it to decrypt the message. QKD is concerned with sharing this key with both Anil and Selvi such that if Kaushik is eavesdropping on the transmission, everyone will find out and the sharing will be aborted.

Quantum physics can protect against eavesdropping in different ways. One is quantum measurement — the act of measuring the properties of a quantum system, like a photon (the particle of light). According to the rules of quantum physics, a quantum measurement changes the state of the system. If information about the key is encoded in a stream of photons and Kaushik traps and measures them to look for it, the state of the photons will change and Anil and Selvi will know the key has been compromised.

Another way is to use quantum entanglement: when two photons are entangled, any change to one particle will instantaneously change the other. (This is a simplistic description.)

Has QKD been implemented?
Ravindra Pratap Singh of the Physical Research Laboratory, Ahmedabad, wrote in 2023 that standards for different QKD implementations are still a decade away. This said, China currently operates the world's largest QKD network with three quantum satellites and four ground stations.

Experts are also trying to implement QKD across longer distances. Since the early 1990s, the distance of reliable transmissions has increased to several hundred kilometres, either through fibre-optic cables or free space.

In an October 2024 study, researchers at the Raman Research Institute, Bengaluru, reported the Indian Astronomical Observatory in Hanle, Ladakh, offers the best atmospheric conditions

through which to transmit data for a satellite-based QKD system. The paper's lead author Satya Ranjan Behera said the beam distance would be 500 km.

Does QKD have drawbacks?

QKD on paper can be different from that in the real-world. This is why the U.S. National Security Agency has recommended the use of post-quantum cryptography rather than quantum cryptography. Its criticism is focused on five technical limitations: "QKD does not provide a means to authenticate the QKD transmission source"; "since QKD is hardware-based", QKD networks can't be upgraded or patched easily; "QKD increases infrastructure costs and insider threat risks" that "eliminate many use cases from consideration"; "the actual security provided by a QKD system is not the theoretical unconditional security from the laws of physics... but rather the more limited security that can be achieved by hardware and engineering designs"; and since eavesdroppers can cause a transmission to stop, they can deny the use of a transmission by its intended users (a.k.a. a denial-of-service attack).

The no-cloning theorem of quantum physics also disallows quantum information from being amplified to compensate for losses during transmission.

Relevance: GS Prelims & Mains Paper III; Science & Technology

3. PM Modi awarded Order of Mubarak Al-Kabeer: What is this Kuwaiti honour, its significance

Introduction

Prime Minister Narendra Modi was awarded the Wisam Mubarak al-Kabeer, or the Order of Mubarak the Great, by Sheikh Meshal Al-Ahmad Al-Jaber Al-Sabah, the Amir of Kuwait, recently.

The Order of Mubarak Al-Kabeer is the highest national award of Kuwait.

What is the Order of Mubarak Al-Kabeer?

The Order of Mubarak Al-Kabeer is conferred by the Kuwaiti government on Heads of State, Sovereigns of foreign countries, and on members of foreign royal families as a sign of friendship and goodwill.

Before PM Modi, recipients include Queen Elizabeth II of England, former American Presidents George HW Bush and Bill Clinton, King Salman of Saudi Arabia, former French President Nicolas Sarkozy, among others.

The award was instituted in 1974, in the memory of Mubarak Al Sabah — also known as Mubarak al-Kabeer or Mubarak the Great — who ruled Kuwait from 1896 to 1915. Under his reign, Kuwait got more autonomy from the Ottoman Empire. In 1899, Mubarak signed a deal

with Britain to guard his kingdom from Turkey, effectively becoming a British protectorate. Mubarak is known for playing a major role in shaping the future of Kuwait.

The design of the award changed in 1992, after Kuwait was liberated from Iraq in the year before.

Significance of the award to PM Modi

PM Modi, after receiving the award, dedicated it to "the long-standing friendship between India and Kuwait, to the Indian community in Kuwait and to the 1.4 billion people of India."

A press release from the Ministry of External Affairs said, "The conferment of the award on this historic visit of a Prime Minister of India to Kuwait after 43 years added a special meaning to the occasion."

Before Modi, the last Indian PM to visit Kuwait was Indira Gandhi in 1981.

Kuwait is among the top trading partners of India, with bilateral trade valued at $10.47 billion in 2023-24. It is also India's sixth largest crude supplier, meeting three per cent of the country's energy needs. Indian exports to Kuwait reached $2 billion for the first time, while investments by the Kuwait Investment Authority in India exceed $10 billion.

India and Kuwait have enjoyed friendly relations, with links dating back to pre-oil Kuwait when maritime trade with India was the backbone of its economy. In fact, the Indian rupee remained legal tender in Kuwait until 1961.

Relevance: GS Prelims; Bilateral Relations