ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 17, Issue, 06, pp.33400-33407, June, 2025
DOI: https://doi.org/10.24941/ijcr.48691.06.2025

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

TREES AND POPULATION: A HALF-CENTURY ANALYSIS OF PER CAPITA FOREST AND TREE COVER AVAILABILITY IN INDIA"

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ARTICLE INFO

Article History:
Received 09th March, 2025
Received in revised form
21st April, 2025
Accepted 19th May, 2025
Published online 30th June, 2025

Keywords:

Forest and tree cover, Afforestation, Deforestation, Population.

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ABSTRACT

This study examines the trends in per capita forest and tree cover availability in India over the past 50 years, focusing on the interplay between deforestation, afforestation efforts, and population growth. From 1987 to 2021, India has experienced significant changes in land use, driven by urbanization, agriculture, and industrialization, contributing to a decline in forest cover. Despite these challenges, various government initiatives, such as the National Afforestation Programme and the Green India Mission, have aimed to increase tree cover and promote sustainable forestry practices. Using data from the Forest Survey of India (FSI) and demographic statistics, the analysis reveals fluctuating trends in per capita tree availability, with an overall decline until the early 2000s, followed by gradual recovery in recent years due to increased afforestation efforts. However, the growing population continues to exert pressure on forest resources, complicating conservation efforts. The study underscores that India's rising population and the corresponding demand for resources have significantly impacted forest and tree cover. From 1987 to 2021, the per capita availability of forests steadily decreased, reflecting broader environmental strain due to population growth. The per capita availability of forest and tree cover declined from approximately 0.0785 hectares per person in 1987 to 0.0575 hectares in 2021, highlighting the widening gap between forest resources and population growth.

Citation: Naveen Khandelwal Jamshed Zaidi and Swati Gupta. 2025. *"*Trees and Population: A Half-Century Analysis of per Capita Forest and Tree Cover Availability in India"*". International Journal of Current Research, 17, (06), 33400-33407.*

INTRODUCTION

Important of Forest: Forests are crucial ecosystems that support approximately 80% of the world's terrestrial biodiversity, providing habitat for countless species of flora and fauna (FAO, 2020). This biodiversity is vital for ecosystem stability and resilience, allowing ecosystems to adapt to changes and stresses (Newbold et al., 2015). Additionally, forests act as significant carbon sinks, absorbing around 2.6 billion tons of carbon dioxide annually, which is essential for mitigating climate change and reducing global warming (Pan et al., 2011; Grassi et al., 2018). They also influence local and regional climates by regulating temperatures and precipitation patterns. Furthermore, forests play a critical role in protecting soil from erosion, maintaining soil fertility, and regulating the water cycle. They help sustain groundwater levels and reduce flooding risks by absorbing excess rainfall, while the root systems of trees stabilize soil, preventing landslides and promoting healthy watershed management (Baker et al., 2013). Economically, forests provide a wide range of products, including timber, non-timber forest products (NTFPs), and medicines, with over 1.6 billion people relying on them for their livelihoods, particularly in rural areas (FAO, 2020). Beyond economic benefits, forests hold significant cultural importance for many communities, offering recreational opportunities that enhance physical and mental well-being, contributing to quality of life through spaces for tourism, recreation, and spiritual enrichment (Burgess et al., 2019).

Forest Cover: Between 1987 and 1999, India's forest cover decreased from 640,819 km² to 637,293 km². However, between 1999 and 2003, some progress was made, with the forest cover rising to 678,333 km², which is 20.64% of the total land area of the country. At this point, the Government of India set targets to achieve 25% forest cover by 2007 and 33% by 2012 (NFCR, 2006). Despite these goals, by 2021, India had only 21.71% of its land area under forest cover and 24.62% under both forest and tree cover (ISFR, 2021) (Table 2). Even after seven decades since 1952, a significant gap remains between the planned and actual outcomes (Pradeep and Sandeep, 2023).

Trees Outside Forest (TOF): Trees Outside Forest (TOF), are defined as 'trees growing outside the forest'. In India, trees growing outside the recorded forest areas (RFA) are termed as TOF. Trees Outside Forest (TOF), are found in diverse formations in the rural and urban landscapes in the country like small woodlots, block plantations, trees along linear features such as roads, canals, bunds, etc and scattered trees on farmlands, agricultural lands, homesteads, community lands and urban areas. TOF play a significant role in livelihood of rural and urban people of the country. They also act as important source of timber and fuel wood, contribute in carbon sequestration and conservation of biodiversity, provide habitat for wildlife, stabilize microclimate etc. They make critical contribution to the sustainable agriculture, food security and rural household economies. They supply many products and services similar to forests. They protect crops and the soil against water and wind erosion, thus combating drought and desertification and protecting water resources.

Table 1. India's forest cover during 1987-2007

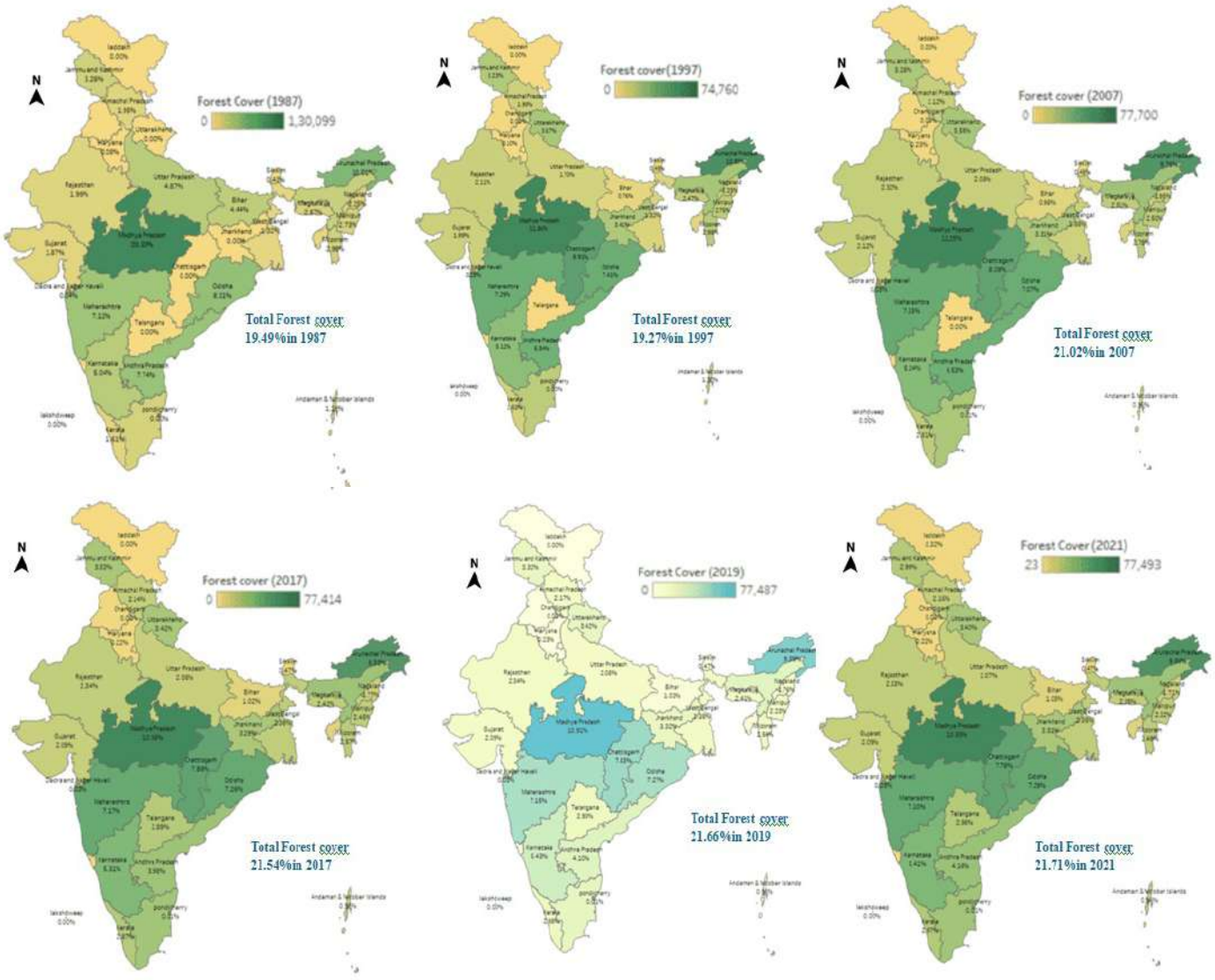
Year	Forest cover (km2)	% of total area of country	Increase (+) or decrease (-) (%)
1987	640,819	19.49	
1989	638,804	19.43	(-)0.31
1991	639,364	19.45	(+) 0.09
1993	639,386	19.45	No change
1995	638,819	19.43	(-) 0.08
1997	633,397	19.27	(-)0.85
1999	637,293	19.39	(+) 0.61
2001	675,538	20.55	(+) 6.0
2003	678,333	20.64	(+) 0.4
2005	677,088	20.60	(-) 0.18
2007	690,899	21.02	(+) 2.0

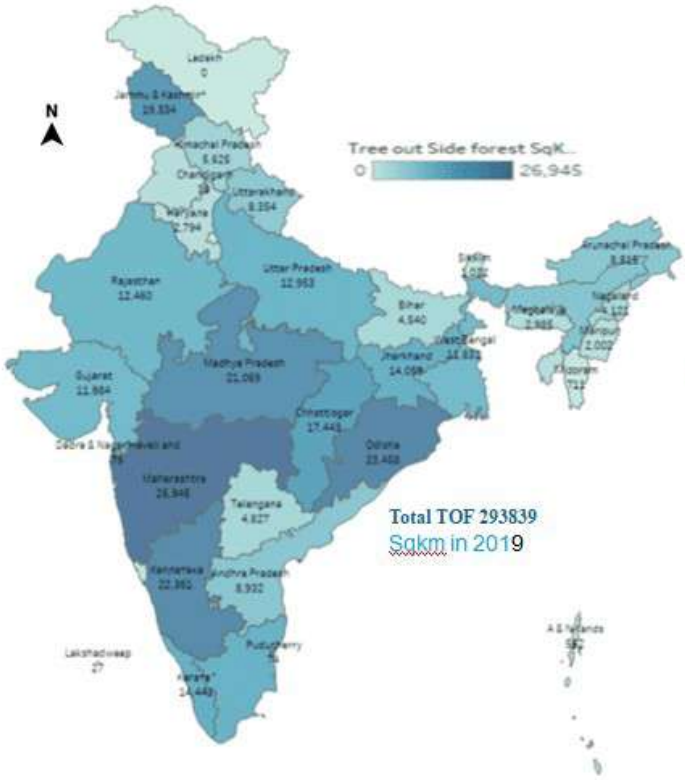
Source: FSI Reports 1987 to 2007

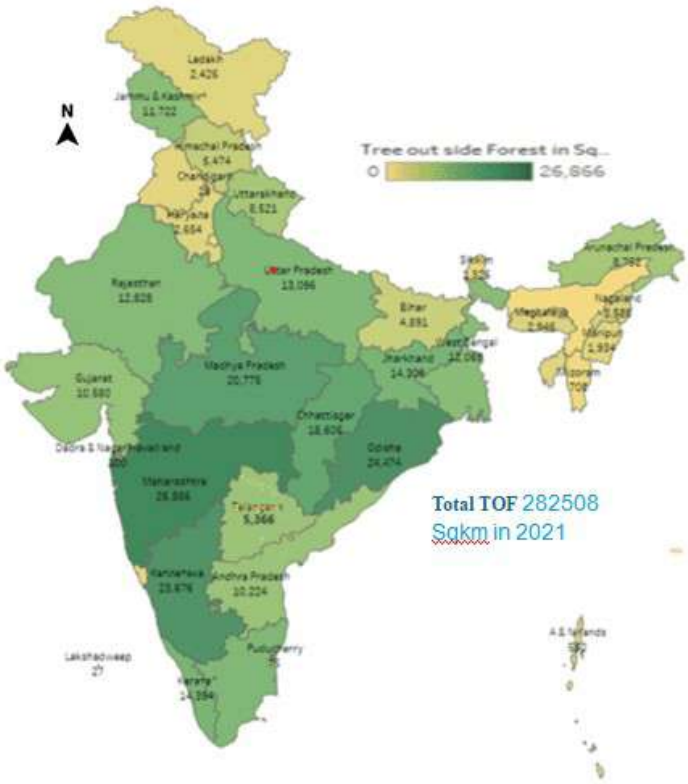
Table 2. India's forest cover during 2011 to 2021 (ten years)

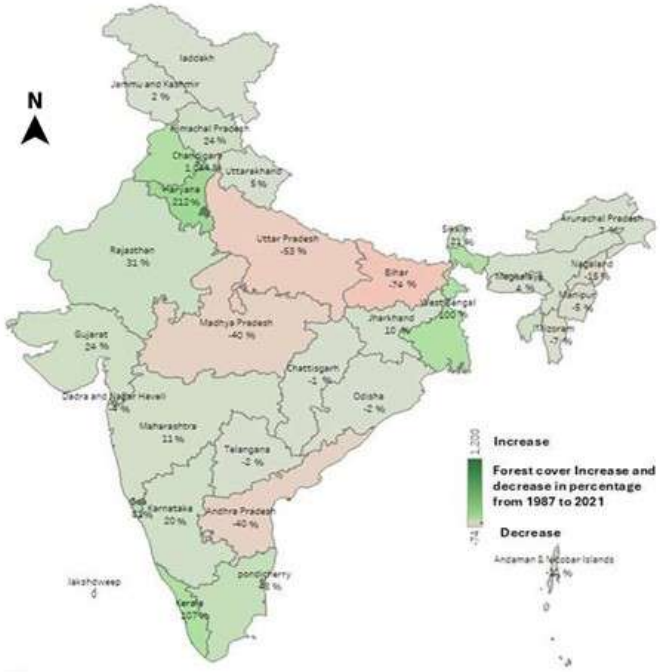
Year	Forest cover (km2)	% of total area of country	Increase (+) or decrease (-) (%)	Tree cover (km2)	% of total area of country	Increase (+) or decrease (-) TreeCover (%)	Forest and tree cover (km2)	Increase (+) or decrease (-) (%)
2011	692,027	21.00	-	90,844	2.76	-	782,871	-
2013	697,898	21.23	(+) 0.85	91,266	2.78	+(0.5)	789,164	(+) 0.80
2015	701,673	21.34	(+) 0.54	92,572	2.82	+(1.4)	794,245	(+) 0.64
2017	708,273	21.54	(+) 0.94	93,815	2.85	+(1.3)	802,088	(+) 0.98
2019	712, 249	21.66	(+) 0.56	95,027	2.89	+(1.3)	807,276	(+) 0.64
2021	713,789	21.71	(+) 0.22	95,748	2.91	+(0.8)	809,537	(+) 0.28

Source: FSI Reports 2011 to 2021









Species wise distribution of TOF in Rural Areas: In India, various tree species are commonly utilized in Tree Outside Forests (TOF) systems, contributing to the country's agroforestry, environmental sustainability, and economic prosperity. Top 20 tree speciesare adapted to different agro-climatic conditions and provide multiple benefits, such as timber, fuelwood, fodder, fruits, medicinal properties, and soil conservation*., (1. Mangifera indica 2. Azadirachta indica 3.Acacia arabica 4. Cocos nucifera 5. Butea monosperma 6. Tectona grandis 7. Zizyphus mauritiana 8. Eucalyptus species 9. Areca catechu* 10. *Hevea brasiliensis 11. Prosopis juliflora 12. Borassus flabelliformis 13. Grewia oppositifolia 14. Prosopis cineraria 15. Populus species 16. Leucaena leucocephala 17. Madhuca latifolia 18. Dalbergia sissoo 19. Terminalia tomentosa 20. Pinus excelsa) used in TOF in India.*

Species wise distribution of TOF in Urban Areas: In urban areas, Tree Outside Forests (TOF) play an important role in enhancing the environment, improving air quality, providing shade, and supporting biodiversity. The following species are among the top 20 commonly used in urban areas in India, each offering unique benefits to the urban ecosystem. (1. *Cocos nucifera 2. Areca catechu 3. Mangifera indica 4. Azadirachta indica 5. Hevea brasiliensis 6. Artocarpus heterophyllus 7. Tectona grandis 8. Psidium guyava 9. Eucalyptus species 10. Moringa species 11. Leucaena leucocephala 12. Prosopis juliflora 13. Melia azadirachta 14. Acacia auriculiformis 15. Swietenia mahagoni 16. Syzygium cumini 17. Anacardium occidentale 18. Morinda oleifera 19. Pongamia pinnata 20. Borassus flabelliformis*

Deforestation in India: The first estimate by FAO calculated an annual gross deforestation rate of 0.6% between 1981 and 1990 for

India, where the scale of reporting is unknown and areas of afforestation were not included11. The second estimate by Ravindranath and Hall39 suggested India's annual net deforestation to be 0.04% between 1982 (1: 1 million scale) and 1990 (1: 250,000 scale). Another estimate by Ravindranath et al**.** suggested India's annual net deforestation to be 0.07% between 1981–83 and 1985–87 based on FSI assessment. These estimates are widely dissimilar due to scale, definition, methodology of classification, quality of hard copy images and inclusion/ exclusion of afforestation. Such inequality in estimates ofthe rate and extent of deforestation calls for more careful regional level or locale-specific studies. Even though significant progress has been made in the protection of forest cover, gross deforestation continues as a major impediment. However, the speed of deforestation is likely to be less compared to the period 1970–90. The net and gross deforestation estimates of Indian forests by FSI are shown in Table 1. shows the percentage of net deforestation and gross deforestation respectively. It should be noted here that although the percentage of net rate of deforestation shows both negative and positive values, the gross rate of deforestation constantly shows negative values due to ongoing human-induced land-use changes for various economic purposes.

Policies

1. National Forest Policy (1988): Aims to maintain ecological balance, increase forest cover, and promote community involvement in forest management. It emphasizes sustainable forest management and recognizes the importance of biodiversity.
2. National Afforestation Programme: Focuses on the regeneration of degraded forests and increasing forest cover through community participation and afforestation efforts.
3. National Biodiversity Action Plan: Aims to conserve biodiversity, which includes forest ecosystems, and promotes sustainable use of biological resources

Afforestation in India: Afforestation in India has gained prominence as a strategy to combat deforestation, enhance biodiversity, and mitigate climate change. The Indian government, alongside various NGOs and community initiatives, has implemented several programs aimed at increasing forest cover through afforestation efforts.

Table 3. deforestation/ Afforestation (% per year)

Year	Area	% of total area of country	Change in Sq Km	Change in %	deforestation/ Afforestation (% per year)
1987	640,819	19.49	-	-	-
1989	638,804	19.43	-2,015	(-)0.31	(-) 0.155
1991	639,364	19.45	560	(+) 0.09	(+) 0.045
1993	639,386	19.45	22	No change	No change
1995	638,819	19.43	-567	(-) 0.08	(-) 0.04
1997	633,397	19.27	-5,422	(-)0.85	(-) 0.42
1999	637,293	19.39	3,896	(+) 0.61	(+) 0.305
2001	675,538	20.55	38,245	(+) 6.0	(+) 3.0
2003	678,333	20.64	2,795	(+) 0.4	(+) 0.2
2005	677,088	20.60	-1,245	(-) 0.18	(-) 0.09
2007	690,899	21.02	13,811	(+) 2.0	(+) 1.0

(source: FSI)

Table 3. deforestation/ Afforestation (% per year)

Year	Forest and tree cover (km2)	% of total area of country	Change in Sq Km	Change in %	deforestation/ Afforestation (% per year)
2011	782,871	23.76	-	-	-
2013	789,164	24.01	6,293	(+) 0.80	(+)0.4
2015	794,245	24.16	5,081	(+) 0.64	(+)0.32
2017	802,088	24.39	7,843	(+) 0.98	(+)0.49
2019	807,276	24.55	5,188	(+) 0.64	(+)0.32
2021	809,537	24.62	2,261	(+) 0.28	(+)0.14

(source: FSI)

Policy and Act for Forest Management: Forest management in India is governed by a combination of laws, policies, and regulations aimed at sustainable forest conservation and management. Here's an overview of the key components:

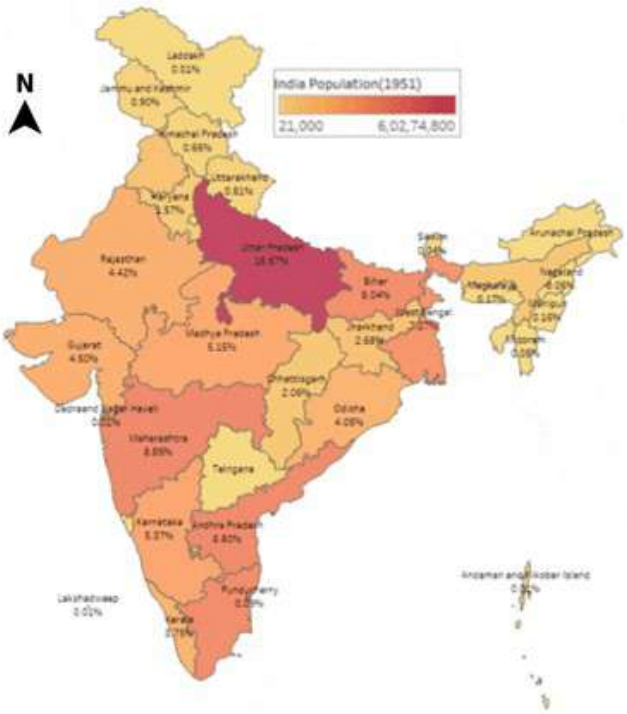
Legal Framework

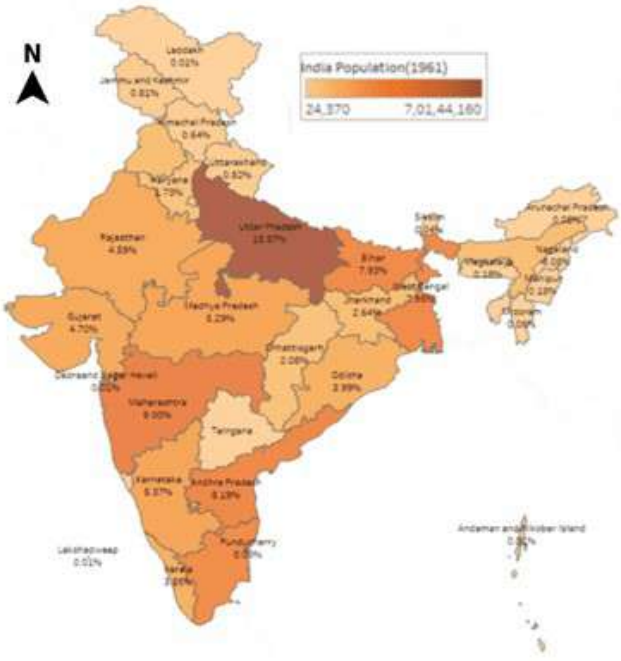
1. Forest Conservation Act (1980): This act regulates the deforestation of forests and requires prior approval from the central government for any diversion of forest land for non-forest purposes.
2. Wildlife Protection Act (1972): This act provides for the protection of wildlife and their habitats, establishing protected areas like national parks and wildlife sanctuaries.
3. Environment Protection Act (1986): It addresses environmental conservation and sets standards for environmental quality, impacting forest management practices.
4. Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act (2006): This act recognizes the rights of forest-dwelling communities over land and resources, emphasizing the need for their involvement in forest management.

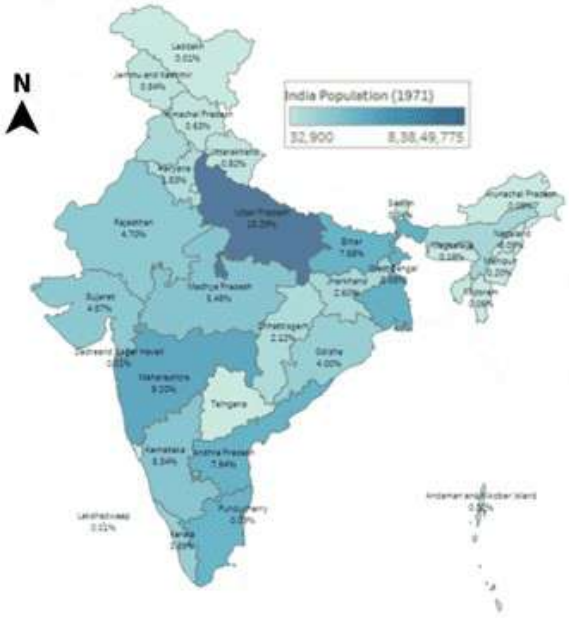
- Van Mahotsav (translated as "Tree Festival") is an annual tree-planting festival celebrated in India, typically observed in the first week of July. It was initiated in 1950 by K. M. Munshi, then Union Minister for Agriculture and Food, to raise awareness about the importance of trees, forest conservation, and afforestation. *Tewari, V.P.&Singh, S. (2009).*
- Ek Ped Maa Ke Naam" (translated as "One Tree in the Name of Mother") is a unique afforestation initiative in India that encourages people to plant trees in honor of their mothers. The campaign aims to blend environmental conservation with emotional and cultural values, promoting tree planting as a tribute to one's mother. It has gained momentum in recent years, particularly in states like Madhya Pradesh, and has been tied to raising environmental awareness and preserving India's ecological balance. *Meena, & Sharma, (2022).*
- Nagar Van Yojana (Urban Forest Scheme) is an initiative launched by the Government of India to create and develop forests in urban areas. The scheme is aimed at increasing green cover and improving the quality of urban environments by developing forests within city limits. It was introduced under the broader framework of the National Afforestation Programme to address the growing need for green spaces in

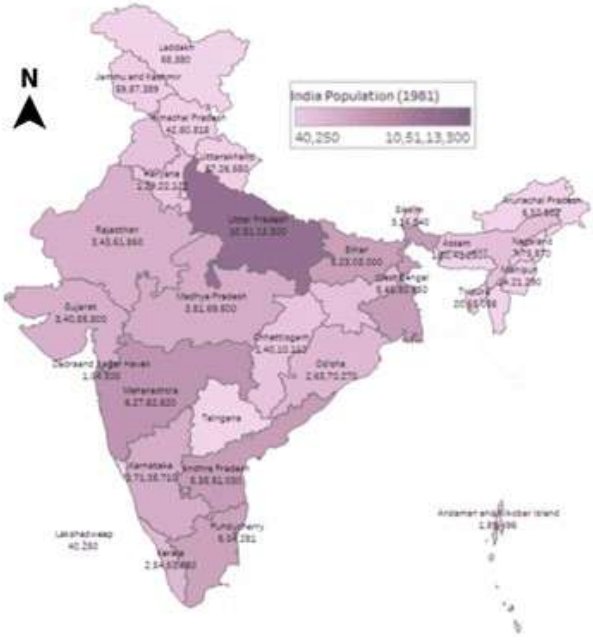
urban landscapes that are rapidly expanding and facing ecological pressures due to urbanization. *Chand, & Singh, (2020).*

- CAMPA (Compensatory Afforestation Fund Management and Planning Authority The CAMPA Fund is designed to support afforestation and regeneration activities by utilizing funds collected from organizations when forest land is diverted for non-forest purposes under the Forest Conservation Act, 1980. The goal is to restore the ecological balance that may be disrupted by development projects.
- National Afforestation Program (NAP) is a flagship scheme of the Government of India aimed at restoring forest cover, enhancing ecosystem services, and promoting the sustainable use of forest resources. Managed by the National Afforestation and Eco-Development Board (NAEB) under the Ministry of Environment, Forest and Climate Change (MoEFCC), the program plays a critical role in afforestation and reforestation activities across the country.
- Nationally Determined Contributions (NDCs) are at the core of the Paris Agreement (2015), an international treaty on climate change. NDCs represent each country's individual climate action plan to reduce greenhouse gas (GHG) emissions and adapt to the impacts of climate change. These contributions outline how countries intend to meet their climate goals in line with limiting global temperature rise to well below 2°C above pre-industrial levels, with efforts to limit it to 1.5°C.









- The Green India Mission (GIM) is one of the eight missions under India's National Action Plan on Climate Change (NAPCC). Launched in 2014, the mission aims to protect, restore, and enhance India's diminishing forest cover, while simultaneously addressing climate change concerns by enhancing carbon sequestration. It is an essential part of India's effort to adapt and mitigate the impacts of climate change through forest and ecosystem conservation.

Several states in India, including Telangana, Uttar Pradesh, and Rajasthan**,** have played a crucial role in increasing the country's forest cover through extensive afforestation programs, conservation policies, and public participation initiatives.

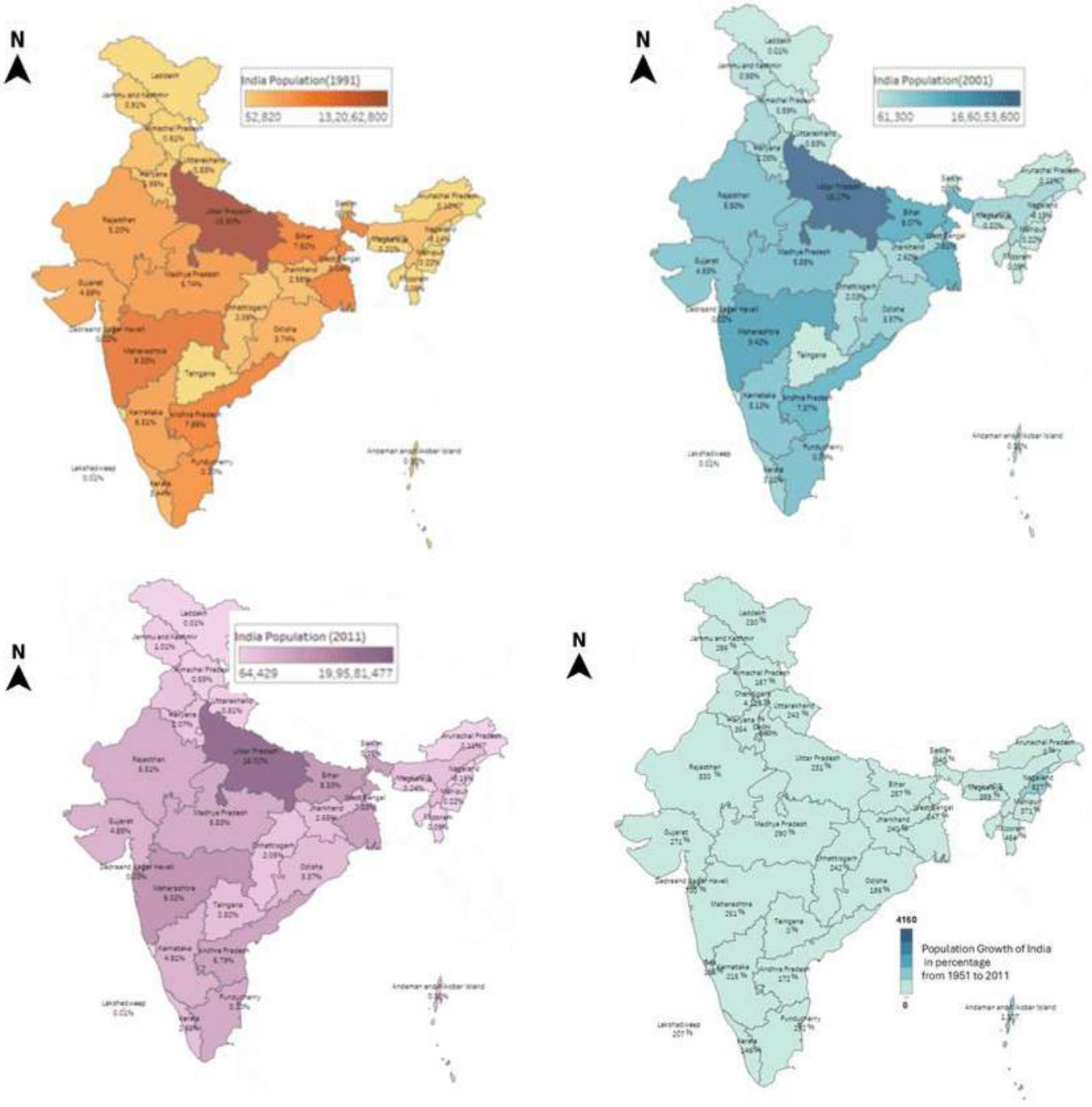
Telangana: Telangana has emerged as a leader in afforestation through its ambitious Haritha Haram program, launched in 2015. This initiative aims to increase green cover by planting 230 crore saplings, focusing on degraded forest restoration, urban greening, and agroforestry. The state has successfully expanded forest cover and tree density, particularly in urban and semi-urban areas, contributing significantly to India's overall green growth.

Uttar Pradesh: Uttar Pradesh has implemented massive plantation drives, setting world records for tree planting. Through the Mission Green Uttar Pradesh and annual Van Mahotsav celebrations, the state has planted millions of saplings along highways, riverbanks, and urban areas. From 2015 to 2021, the state's forest cover increased steadily, reflecting its commitment to environmental sustainability, biodiversity conservation, and climate resilience.

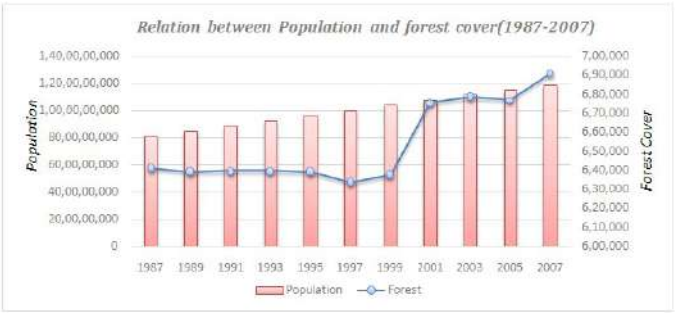
Rajasthan: Despite its arid and semi-arid climate, Rajasthan has focused on desert afforestation, water conservation, and sustainable forestry. Initiatives such as the Greening the Thar Desert project and afforestation in drylands have contributed to an increase in forested areas. The state has also promoted agroforestry and community-led afforestation**,** ensuring sustainable land use while combating desertification and soil erosion.

Population Growth in India over the Last 50 Years: India has experienced significant population growth over the past five decades, transitioning from a population of approximately 548 million in 1971 to over 1.4 billion in 2021. This growth has been influenced by various factors, including declining mortality rates, improved healthcare, and cultural factors (Census of India, 2021).

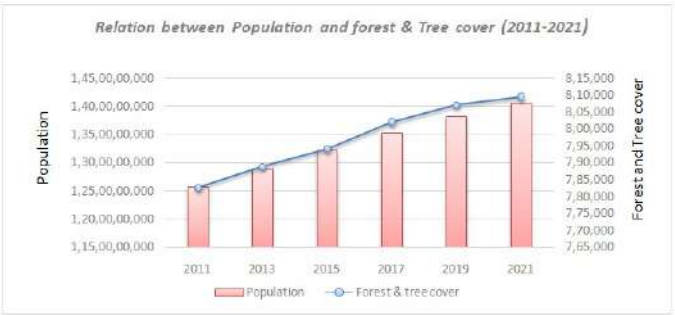
Population Growth relationship with forest cover: The relationship between population growth and forest area is complex and multifaceted. Several trends can be observed from the data:



1. **Population Growth and Early Decline in Forest Area (1987-1997):** Between 1987 and 1997, as the population grew steadily, there was a slight decline in forest area, from 640,819 sq km to 633,397 sq km. This decline could be due to various factors such as urbanization, agricultural expansion, and deforestation to meet the needs of a growing population. As more land is required for agriculture, housing, and infrastructure, forests are often cleared.
2. **Recovery of Forest Area (1997-2007):**
   - Despite the continued growth in population during the second half of this period, forest area showed a significant recovery. By 2007, the forest area increased to 690,899 sq km, higher than in 1987. This trend may indicate that conservation efforts, reforestation initiatives, and better land management practices began to take effect during this period.
   - Technological advancements in agriculture, along with policies focused on environmental sustainability, may have helped reduce the pressure on forests, allowing them to recover even as the population grew.



3. **Forest and tree cover and population relation (2011-2021):** From 2011 to 2021, India witnessed steady growth in both forest and tree cover as well as its population. Forest and tree cover increased significantly, from 782,871 sq km in 2011 to 809,537 sq km in 2021, reflecting a rise of 26,666 sq km over the decade. During the same period, India's population grew from 1.26 billion people in 2011 to 1.41 billion in 2021, an increase of approximately 150 million people. Despite the increasing population, which typically puts pressure on land resources, India has managed to expand its forest and tree cover, thanks to efforts in sustainable forest management, afforestation, and reforestation. This positive correlation between population growth and forest cover demonstrates that with effective conservation strategies and responsible land use practices, it is possible to support a growing population while simultaneously increasing tree and forest areas. This trend underscores the importance of balancing development with environmental sustainability to ensure the long-term health of India's ecosystems.

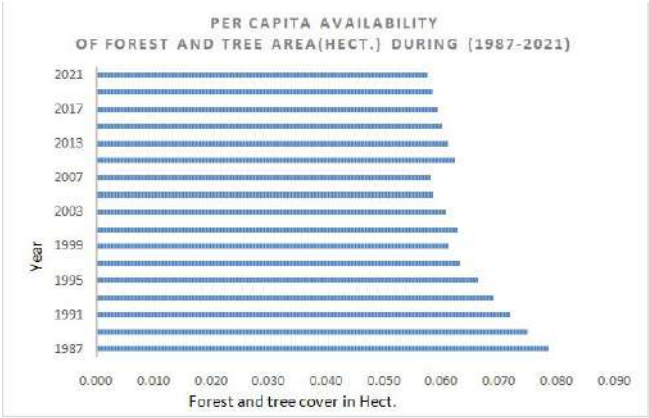


Per Capita Availability of Forest and Tree Cover in India (1987-2021): India, with its vast landmass and dense population, faces a unique challenge in managing its natural resources, particularly its forests. The relationship between India's population growth and the availability of forest resources has important implications for its environmental sustainability.

Trends in Per Capita Forest Area

From the calculations, we observe the following trends in per capita forest area:

1. ***Decreasing Availability of Forests:*** The per capita availability of forest and tree cover has declined over the years. In 1987, each person had access to about 0.0785 hectares of forest. By 2021, this had decreased to approximately 0.0575 hectares per person. This reduction reflects the combined effect of a rising population and relatively slow increases in forest cover.
2. ***Slight Increase in Forest Area:*** While the total forest area increased from 64.08 million hectares in 1987 to 80.95 million hectares in 2021, the increase was not proportional to the population growth. This indicates that despite efforts in afforestation and forest conservation, India is struggling to maintain sufficient forest cover relative to its population size.
3. ***Population Growth and Pressure on Forests:*** India's population has grown by over 70% from 1987 to 2021, from 815 million to over 1.4 billion people. This sharp rise has created increasing demand for land, resources, and urban space, putting additional pressure on forest areas. The relatively slow expansion of forest cover compared to population growth has led to a declining per capita forest area.



CONCLUSION

India has made significant strides in forest management through a combination of legal frameworks, policies, and afforestation initiatives. The implementation of key laws such as the Forest Conservation Act (1980) and the Wildlife Protection Act (1972), along with national policies like the National Forest Policy (1988) and Green India Mission, has played a crucial role in conserving and expanding forest cover. Various afforestation programs, including Haritha Haram in Telangana, large-scale plantation drives in Uttar Pradesh, and desert afforestation in Rajasthan, have demonstrated the potential of state-led efforts in improving green cover. The relationship between population growth and forest cover in India is dynamic and multifaceted. While the initial years (1987-1997) showed a decline in forest area due to urbanization and agricultural expansion, subsequent decades witnessed a recovery, largely driven by conservation policies, afforestation efforts, and improved land management practices. Despite continuous population growth, India has successfully expanded its forest and tree cover, particularly from 2011 to 2021, showcasing the effectiveness of sustainable forestry initiatives. However, the per capita availability of forest cover has steadily declined due to the rapid population increase, highlighting the ongoing challenge of balancing environmental sustainability with development needs. While afforestation and reforestation efforts have contributed to overall forest expansion, they have not kept pace with population growth, leading to reduced per capita forest resources. Going forward, it remains crucial for India to strengthen its conservation strategies, promote responsible land-use policies, and integrate sustainable development practices to ensure that both human and ecological needs are met.

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