

THE NILGIRIS DISTRICT DECARBONISATION ACTION PLAN



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“Tamil Nadu has always led the nation in showing how growth and responsibility can go hand in hand. We are steadily building on our actions toward becoming a Net-Zero economy well before 2070. These District Decarbonisation Action Plans take this commitment deeper by bringing climate action closer to the people, to our villages, towns, and industries. When every district and every citizen joins hands, Tamil Nadu will demonstrate how sustainability can take root in local action and collective responsibility. ”

Thiru M.K.Stalin

Honourable Chief Minister of Tamil Nadu



“ For Tamil Nadu, economic progress and environmental care go hand in hand and they are central to how we plan and govern. These District Decarbonisation Action Plans reflect our commitment to ensuring that development also builds climate resilience. They will guide each district to grow responsibly, aligning prosperity with the health of our land, air, and water. This is how we see the future of Tamil Nadu where fiscal discipline, environmental stewardship, and people’s well-being move forward together. ”

Thiru Thangam Thennarsu

**Honourable Minister for Finance,
Environment and Climate Change, Tamil Nadu**



“ The District Decarbonisation Action Plans strengthen Tamil Nadu’s commitment to integrating climate priorities into development planning. They bring together policy, people, and business to act on shared goals of resilience and sustainability. This approach reflects our focus on turning data and collaboration into practical outcomes that safeguard our environment and support inclusive growth. This is where the strength of Tamil Nadu truly lies, in turning science and policy into action that uplifts people and protects nature. ”

Tmt. Supriya Sahu, I.A.S.

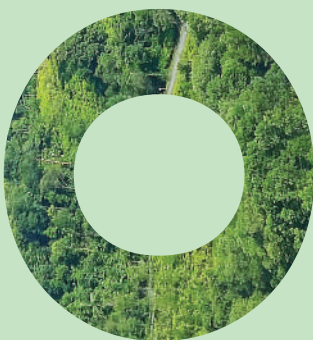
**Additional Chief Secretary to Government, Environment,
Climate Change & Forest Department, Tamil Nadu**



“ The District Decarbonisation Action Plans reflect Tamil Nadu’s participatory and bottom-up approach to climate action. They combine data, local experience, and cross-sector coordination to help districts plan and act with clarity. Through collaboration between departments, industries, and communities, TNGCC is working to ensure that every local effort contributes meaningfully to the state’s long-term climate goals. ”

Thiru A.R. Rahul Nadh, I.A.S.

**Director, Department of Environment and
Climate Change, Tamil Nadu**



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List of Abbreviations

AES	Aggressive Effort Scenario
AFOLU	Agriculture, Forestry and Other Land Use
AIF	Agricultural Infrastructure Fund
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AR2	Second Assessment Report of IPCC
AR6	Sixth Assessment Report of IPCC
ASP	Annual Sequestration Potential
AWS/ARG	Automatic Weather Station/ Automatic Rain Gauge
BAT	Best Available Technologies
BCS	Baseline Case Scenario
BEE	Bureau of Energy Efficiency
BPKP	Bharatiya Prakritik Krishi Paddhati
BRP	Balanced Ration Programme
CAGR	Compounded Annual Growth Rate
CAMPA	Compensatory Afforestation Fund Management and Planning Authority Fund
CBG	Compressed Biogas
CCC	Carbon Credit Certificates
CCTS	Carbon Credit Trading Scheme
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CH ₄	Methane
CNG	and Bio- Compressed Natural Gas
CO ₂	Carbon Dioxide
COP	Coefficient of Performance
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CSD	Carbon Stock Density
CSR	Corporate Social Responsibility

DEOC	District Emergency Operations Centre
DEWAT	Decentralised Wastewater Treatment Facilities
DHS	Demographic and Health Surveys
DRE	Decentralised Renewable Energy
ECA	Energy Conservation Act
ECBC	Energy Conservation Building Code
EEFP	Energy Efficient Fans Platform
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of Hybrid and Electric Vehicles
FSI	Forest Survey of India
FSTP	Faecal Sludge treatment plant
FY	Financial Year
GHG	Greenhouse Gases
GIM	Green India Mission
GTNM	Green Tamil Nadu Mission
HSD	High Speed Diesel
HT	High Transmission
HVAC	Heating, Ventilation, and Air Conditioning
ICE	Internal Combustion Engine Vehicles
ICM	Indian Carbon Market
IPCC	Intergovernmental Panel on Climate Change
IPPU	The Industrial Processes and Product Use
IR	Interest Rate
IRES	India Residential Energy Survey
JJM	Jal Jeevan Mission
KAVIADP	Kalaigarin All Village Integrated Agriculture Development Programme

KNMT	Kalaigarin Nagarpura Mempattu Thittam
LPG	Liquified Petroleum Gas
LT	Low Transmission
LULC	Land Use and Land Cover
M&E	Monitoring and Evaluation
MES	Moderate Effort Scenario
MLD	Million Liters Per Day
MTOE	Million Tonnes of Oil Equivalent
N ₂ O	Nitrous Oxide
NADP	National Agriculture Development Programme
NAP	National Afforestation Program
NBP	National Bio-Energy Programme
NBR	Nilgiris Biosphere Reserve
NDC	Nationally Determined Contributions
NECP	National Efficient Cooking Programme
NEERI	National Environmental Engineering Research Institute
NEHC	Nilgiris Ecotourism & Heritage Council
NEMMP	National Electric Mobility Mission Plan
NET-HC	Nilgiris Ecotourism and Tribal Heritage Council
NFHS	National Family Health Survey
NICRA	National Innovations in Climate Resilient Agriculture
NMEEE	National Mission for Enhanced Energy Efficiency
NMSA	National Mission for Sustainable Agriculture
NMT	Non Motorised Transport
NSCICM	National Steering Committee for Indian Carbon Market
ODF	Open Defecation Free
PAT	Perform Achieve and Trade
PM E-Drive	Pradhan Mantri Electric Drive Revolution in Innovative Vehicle Enhancement

PM KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PMU	Project Management Unit
PPAC	Petroleum Planning and Analysis Cell
PPP	Public Private Partnership
RPO	Renewable Purchase Obligation
RTO	Regional Transport Office
SBM	Swachh Bharat Mission
SHG	Self-Help Groups
SMAF	Sub-Mission on Agro-Forestry
SRI	System of Rice Intensification
STP	Sewage Treatment Plants
SWM	Solid Waste Management
TANSEED	Tamil Nadu Startup Seed Grant Fund
TANSIM	Tamil Nadu Startup and Innovation Mission
TANTEA	Tamil Nadu Tea Plantation Corporation
TCO	Total Cost of Ownership
TEDA	TN Energy Development Agency
TN-SHORE	Tamil Nadu Shore Mission
TNCCM	Tamil Nadu Climate Change Mission
TNGCC	Tamil Nadu Green Climate Company
TNUDP	Tamil Nadu Urban Development Project
TNWM	Tamil Nadu Wetlands Mission
TPD	Tonnes per Day
TPES	Total Primary Energy Supply
UGD	Underground Drainage
ULB	Urban Local Bodies
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary Carbon Market
VCS	Verra

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Preamble

The District Decarbonisation Action Plan for the Nilgiris has been formulated with the overarching vision of transforming the region into a climate-smart, ecologically secure, and economically resilient geography. Grounded in scientific assessments and stakeholder consultations, the report provides a comprehensive set of sector-wise strategies, emission reduction trajectories, and actionable interventions tailored to the district's unique ecological and socio-economic context. While several of the proposed interventions may carry financial implications and influence economic activities in the short term, the medium- to long-term impacts are expected to deliver substantial and sustained benefits for both the local communities and the ecosystem.

For instance, introducing a cap on tourist influx within the sensitive biosphere areas may initially affect stakeholders in the tourism and transport sectors. However, this measure is vital for preserving the region's ecological integrity and ensuring that tourism remains within the limits of the carrying capacity. In the long run, such an approach will protect the very assets that drive the region's economy—its pristine landscapes and biodiversity—thus securing a steady and sustainable income for communities dependent on eco-tourism and related livelihoods.

Continuing with Baseline Case Scenerio (BCS) practices might seem economically favorable in the immediate term for certain sectors. However, such unregulated growth is likely to result in resource degradation, ecosystem collapse, and eventually, significant economic disruptions and losses. Therefore, the Action Plan emphasises a preventive and forward-looking strategy that integrates decarbonisation, sustainable resource management, and climate resilience into the region's development trajectory.

By balancing ecological sustainability with community well-being, the Action Plan aims to build long-term resilience, promote inclusive growth, and safeguard Nilgiris' unique natural and cultural heritage for future generations.

The report provides a comprehensive decarbonisation and climate action plan for the Nilgiris, highlighting the need for climate resilience and decarbonisation in a clear and accessible manner. It outlines ready-to-implement projects for the near term, sectoral interventions with their abatement/sequestration potential, and a decadal implementation roadmap.

Executive Summary

The Nilgiris district, part of the Nilgiris Biosphere Reserve in the Western Ghats, is rich in biodiversity and home to a wide range of exotic and endangered flora and fauna. The region is renowned for its tea, spices, and a diverse mix of commercial horticulture crops, enabled by its high-altitude (~2,000 m) and temperate climate. The district's unique physio-climatic features – steep terrain, abundant rainfall, and perennial streams – have made the district a strategic location for hydropower generation, with small and medium-scale projects having an installed capacity of ~830 MW, contributing significantly to Tamil Nadu's non-fossil electricity generation.

Further, Nilgiris is a major tourism hub with an annual tourist count of 2.5 million across Ooty, Coonoor, Kotagiri and other hill stations (2022–2024). It faces the challenge of local environmental degradation and increased emissions driven by higher transportation and electricity needs by tourists. Other issues include increased use of nitrogen fertiliser and land-use changes driven by increasing developmental pressures.

However, the pristine forest and shola grasslands offer a huge potential for sequestering carbon. This along with climate smart initiatives that are recommended in this action plan can chart a pathway for the district to become carbon neutral by 2028, contributing further towards Tamil Nadu's vision of becoming carbon neutral well before 2070.



Low Carbon and Resilient Pathways for Nilgiris

Given the fragile ecology and limited carrying capacity of the region, it is imperative to develop a detailed intervention-based action plan across economic sectors to abate GHG emissions, while also building resilience of the district. This plan provides an analysis of the 2022 emissions profile of Nilgiris and projections up till 2050 under different scenarios. In 2022, transport and building sectors together accounted for ~67% (223 ktCO₂e) of the total GHG emissions in Nilgiris. Remaining emissions occurred in livestock (25 ktCO₂e), agricultural soils (22 ktCO₂e), industries (20 ktCO₂e) and agriculture (9 ktCO₂e). These emissions – a gross total of 334 ktCO₂e – were substantially countered by land based sequestration (323 ktCO₂e), leaving a net GHG emissions of 11 ktCO₂e in the district.

In the baseline case scenario (BCS), emissions from the energy sectors are estimated to increase by 16% from 252 ktCO₂e in 2022 to 292 ktCO₂e in 2030, and by 22% to 308 ktCO₂e in 2050 – driven by increased electricity demand and fuel consumption in the transport, buildings, and industries as well as tourist influx. Through introduction of electric vehicles, electrification of heating processes in industries, shift from LPG to electric cookstoves, and solarisation of agriculture pumpsets, the Nilgiris can abate 21% of energy emissions in 2030. Continued and compounding efforts can further result in abatement of 54% of projected energy emissions in 2050.

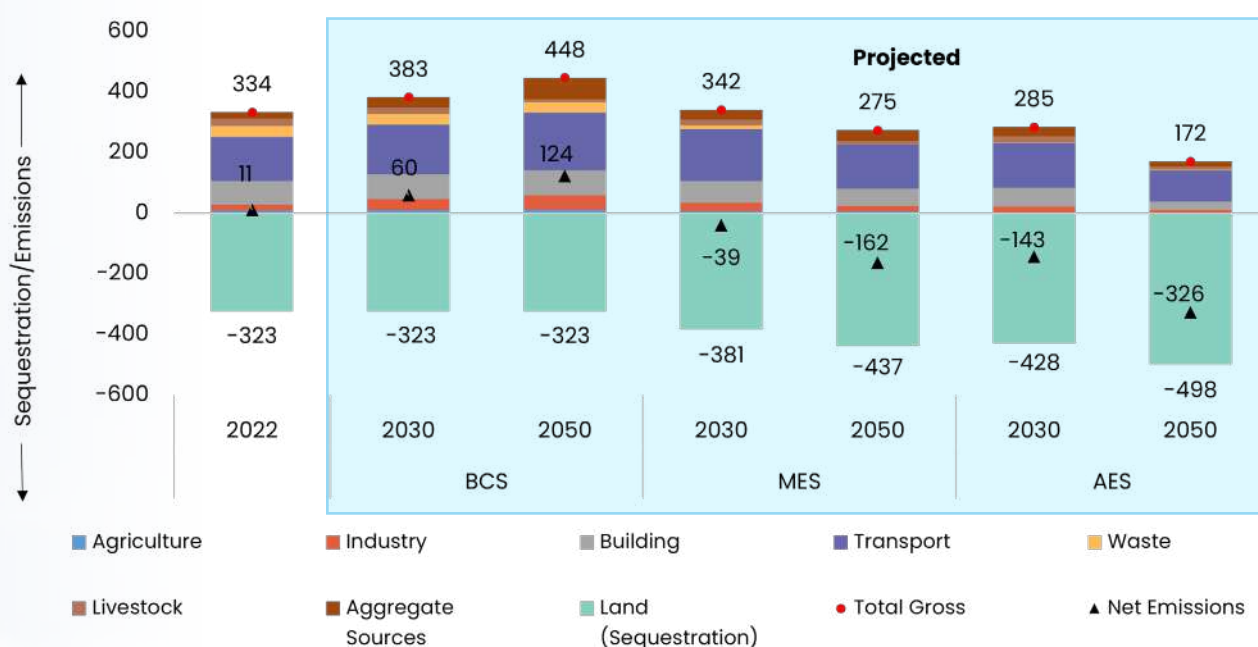


Figure ES1: GHG emissions in Nilgiris in 2022 (actual), 2030 and 2050 (projections) under BCS, MES and AES

Similarly, gross emissions from the non-energy sectors are estimated to increase by 12% – from 82 ktCO₂e in 2022 to 92 ktCO₂e in 2030, and further by 41%, to 116 ktCO₂e in 2050. Use of organic fertiliser and nano-urea, improved waste management, including wastewater, could abate 42% of gross non-energy emissions in 2030 and 74% of projected non-energy emissions in 2050.

Some residual emissions may still occur in transport, building and aggregate sources. Land based sequestration, forests and shola grasslands restoration, along with promoting agroforestry will be the key to offset the remaining emissions. With the ongoing efforts to enhance forest cover expected to continue with the same rigour, the current sequestration level of 323 ktCO₂e (as of 2022) can be sustained under the Business-as-Usual scenario. Furthermore, targeted interventions such as enhancing the carbon stock density, expanding agroforestry in barren and fallow lands and strengthening social forestry are projected to significantly boost annual carbon sequestration—reaching 430 ktCO₂e by 2030 and 492 ktCO₂e by 2050 – enabling the Nilgiris to become carbon neutral by well before 2030. The decarbonisation could further be expedited through policy and regulatory mechanisms (such as a pragmatic cap on vehicular traffic) which would rapidly drive emissions reduction and result in additional abatements over and above the projections

Implementation Projects in Near Term

Implementation of the decarbonisation plan is estimated to require around Rs. 10,000 crores by 2050. This financial requirement could be met phase-wise. In the initial phases, the following key suggested projects could be undertaken to set a foundation for the district's decarbonisation.

The region holds immense potential for piloting decarbonisation strategies, particularly in tourism and tea production. The following projects are identified for early implementation based on their high short- to medium-term impact and ease of implementation.

- 1. Sustainable mobility for tourists:** An average of 20,011 vehicles, including 11,509 cars, 1,341 vans, 637 buses, and 6,524 two-wheelers enter the Nilgiris every day during the peak season for visiting Ooty and other hill stations. By adding 40 electric buses and 1,400 electric autos in Nilgiris by 2030, with routes supporting tourist movements in Ooty, up to 5 ktCO₂e, 1% of the total projected gross emissions by 2030, can be abated each year. Regulatory levers promoting adoption of electric vehicles can be further explored.

Short term interventions	Departments	Expected cost (Rs. Crores)	Available finance
Addition of 40 electric buses by 2030	Nilgiris Regional Transport Office (RTO) and State Transport Department	48	Rs. 11 Crores under PM E-Drive ¹ with a supplementing Rs. 4 Crores under TN EV Policy ² Furthermore, the Rs. 70 Crore allocation made by SPCB to TN Transport Corporation ³ can be explored
Addition of ~1,400 electric autos by 2030		42	Rs. 1.1 Crores under PM E-Drive with a supplementing Rs. 4.2 Crores under TN EV Policy

Given the scale and nature of tourist inflow, targeted low-carbon mobility interventions, including addition of a total of 200 electric buses and 7,400 e-autos by 2050, can abate 25 ktCO₂e or 6% of total gross emissions by 2050, while improving visitor experience and local air quality.

- 2. Sustainable ecotourism:** Nilgiris, a major tourist destination in South India, draws millions of visitors annually, providing vital livelihoods for the local population. However, this influx places significant stress on the district's fragile ecosystem—through increased waste, water demand, and infrastructure pressure. Promoting sustainable tourism offers an opportunity to balance economic benefits with environmental protection and enhance climate resilience.

Short term interventions	Departments	Expected cost (Rs. Crores)	Policies/funding schemes
Designating and developing 'eco-heritage villages' in areas with strong tribal or historic significance (e.g., Tranquebar-style settlements or Toda munds)	Municipal Administration Department, Tourism Department, Forest Department	To be assessed, on case to case basis	Swadesh Darshan 2.0, Corporate SR funding, PPPs, and other national and international donors
Revitalisation of Ooty Lake: Electric/pedal boats, eco-trails, and green-certified amenities, eco-education centre and nature-guided tours			
Fostering ecotourism centric livelihoods: Train locals as eco-guides and support SHGs for eco-souvenir stalls			

- 3. RE installation and electrification in tea factories & other commercial establishments:** Nilgiris is a notable hub for tea production, with factories spread in Ooty alongside Coonoor and Kotagiri. Emissions in tea production occur due to use of fossil fuel (coal/natural gas/firewood) at various stages from withering and rolling, to fermentation, steaming and drying of tea leaves.⁴ By replacing 40% of the fuelwood based heaters with electric heaters in the tea industry by 2030 (and 80% by 2050), as many as 19 ktCO₂e (5% of total projected gross emissions by 2030) can be abated each year. Rooftop solar and captive ground mounted solar plants can further fuel processes in tea factories and other commercial establishments, enhancing the RE capacity and generation in the district and respectively in Ooty.

Short term interventions	Departments to be involved	Expected cost (Rs. Crores)	Available finance
Replacing 40% of fuelwood based heaters with electric heaters	TN Energy Development Agency (TEDA) and the Tamil Nadu Tea Plantation Corporation (TANTEA)	0.035 per heater ⁵	Rs. 1.5 crore of capital subsidy and 0.1 crore of additional capital subsidy (up to 25% of plant or machinery value) under TN MSME Capital Subsidy Scheme
Installation of rooftop solar on Government buildings and other large commercial and industrial setups including TEA industries	TN Energy Development Agency (TEDA), the Industries, the Investment Promotion & Commerce Department, the Tamil Nadu Tea Plantation Corporation (TANTEA)	To be assessed, on case to case basis	

- 4. Adoption of solar pumpsets in agriculture:** Nilgiris is a horticulture rich district, with 60 percent of the cultivable land on slopes such as that of Ooty growing potato, cabbage, carrots, beetroot and other cruciferous vegetables. The growing demand for irrigation, currently met majorly through diesel pumps, can be supported through installation of 1,120 solar pumps of 5HP by 2030 – abating 6 ktCO₂e (2% of the projected gross emissions by 2030) each year.

Short term interventions	Departments	Expected cost (Rs. Crores)	Available finance
Replacement of 1,120 diesel pumps with solar pumps (average capacity 5HP)	Department of Agriculture	35	Rs. 0.03 Crore per off-grid solar pump under PM KUSUM ⁶

- 5. Agro/Social Forestry in fallow and barren lands, enhancement of carbon stock density and restoration of grassland:** The Nilgiris district with its unique blend of forest slopes and cultivated valleys, contains pockets of barren and underutilised lands, that offer significant potential for agro and social forestry interventions. Currently, these lands contribute little to local livelihoods and are vulnerable to erosion and invasive species. By implementing targeted programs of social forests, agro forests and horticulture plantations with native species enhancement of carbon stock density and restoration of grassland, an annual carbon sequestration potential of 105 ktCO₂e, mitigating emissions by 3% can be leveraged, apart from supporting soil conservation, rural livelihoods and improving overall biodiversity of the region.

Short term interventions	Departments	Expected cost (Rs. Crores)	Available finance
- Social and agro forestry in 1819 ha of barren/fallow lands - Restoration of grassland in 14 sq. km - Enhancement of carbon stock density by 2% from 96.22 t/ha to 98 t/ha	Forest department, Municipal Administration Department, Horticulture department	41	Sub-Mission on Agro Forestry (SMAF), Green Tamil Nadu Mission, Green India Mission, State Compensatory Afforestation Fund Management and Planning Authority Fund (CAMPA), Trees Outside Forests in India initiative by MoEFCC and Government of Tamil Nadu

Further, expanding agro/social forestry over an additional 5457 ha, restoring grassland additionally in 42.3 sq.km, enhancing carbon stock density by 6% from 96.22 t/ha to 102 t/ha has the potential to mitigate 174 ktCO₂e by 2050, offsetting gross emissions by 39%.

6. Enhancing domestic wastewater treatment: One of the predominant challenges in the Nilgiris district is handling the domestic wastewater generated, driven by its resident population as well as heavy seasonal tourist inflows, especially in key urban centres and tourist destinations like Ooty, Coonoor and Gudalur. To overcome the risk of untreated discharge while also reducing the strain on existing infrastructure, the proposed intervention aims to achieve 100% treatment of domestic wastewater by 2030, thereby targeting a reduction in projected GHG emissions from 33.4 ktCO₂e under BCS to less than 1 ktCO₂e annually mitigating emissions by 8.69%.

Short term interventions	Departments	Expected cost (Rs. Crores)	Available finance
Scaling up the STP capacity to ~45 MLD, up-grading rural septic systems, establishing 5 new FSTPs at village panchayat cluster level, DEWAT for isolated commercial centres such as resorts and homestays	Municipal Administration department, Tamil Nadu Water Supply and Drainage Board, Rural Development and Panchayat Raj Department, Tamil Nadu Pollution Control Board	133	Government initiated with possibilities for gap funding through private, CSR, Swachh Bharat Mission, Tamil Nadu Urban Development Project. Namakku Namae Thittam, Kalaingar Nagarpura Mempattu Thittam

7. Sustainable agricultural practices: The Nilgiris district, known for its diverse horticulture and tea plantations, faces challenges in the form of soil degradation and resulting emissions from chemical intensive farming practices that threaten long term productivity and ecosystem health. This intervention aims to promote natural farming practices to offset agriculture soil emissions of around 5 ktCO₂e/year by 2030, with mitigating emissions by 1.39% added co-benefits of enhancing soil fertility, reducing the dependence on synthetic fertilisers and safeguarding water quality in the sensitive hill region.

Short Term Interventions	Departments	Expected Cost (Rs. Crores)	Available Finance
10840 Ha (15%) of net sown area transitioned to organic fertiliser; 15% of urea demand met through nano urea	Agriculture department, Horticulture department	11	National Mission for Sustainable Agriculture, Mission for Integrated Development of Horticulture, National Agriculture Development Program

Further, transitioning 54,199 Ha (75%) of agricultural land to organic farming and meeting 13% of urea demand with nano urea by 2050 could mitigate 54 ktCO₂e annually by 2050, mitigating gross emissions by 0.69%. Allocations can be leveraged through PM KUSUM, PM E-DRIVE/Tamil Nadu EV Policy, National Mission for Sustainable Agriculture, Tamil Nadu Urban Development Project (TNUDP) III, Namakku Namae Thittam and various other government initiatives. Private partnerships and market instruments can further supplement these efforts.

KEY SECTORAL INSIGHTS



Current development pathways are expected to contribute to a swift growth in GHG emissions, which were largely stable throughout the past decade. However, early interventions such as enhanced sequestration and responsible management of vehicular traffic could enable Nilgiris to become carbon neutral well before 2030.

Gross GHG emission (excluding land based sequestration), which remained stable at 334 ktCO₂e in the past decade, is expected to reach 448 ktCO₂e by 2050. However, with the available set of technologies and decarbonisation measures, 62% of these economy-wide emissions can be abated, with residual emissions in both energy and non-energy sectors. Considering existing as well enhanced land-based sequestration, the net GHG emissions could drop to a net negative of 326 ktCO₂e by 2050 (Figure ES2).

Nilgiris has already embarked on the journey to become carbon neutral, undertaking a slew of measures, including planting 60,000 native trees in Nilgiris with another ~19000 saplings across Udthagamandalam, Coonoor, Kundha, Kotagiri, Gudalur and Pandalur for enhancing the forest cover. The district can build upon this momentum to amplify land based sequestration. Recent initiatives aimed at promoting responsible vehicular traffic management in Ooty and other tourist destinations in Nilgiris through limiting daily vehicle volume to 6,000 on weekdays and 8,000 on weekends could further reduce the emissions significantly.⁷

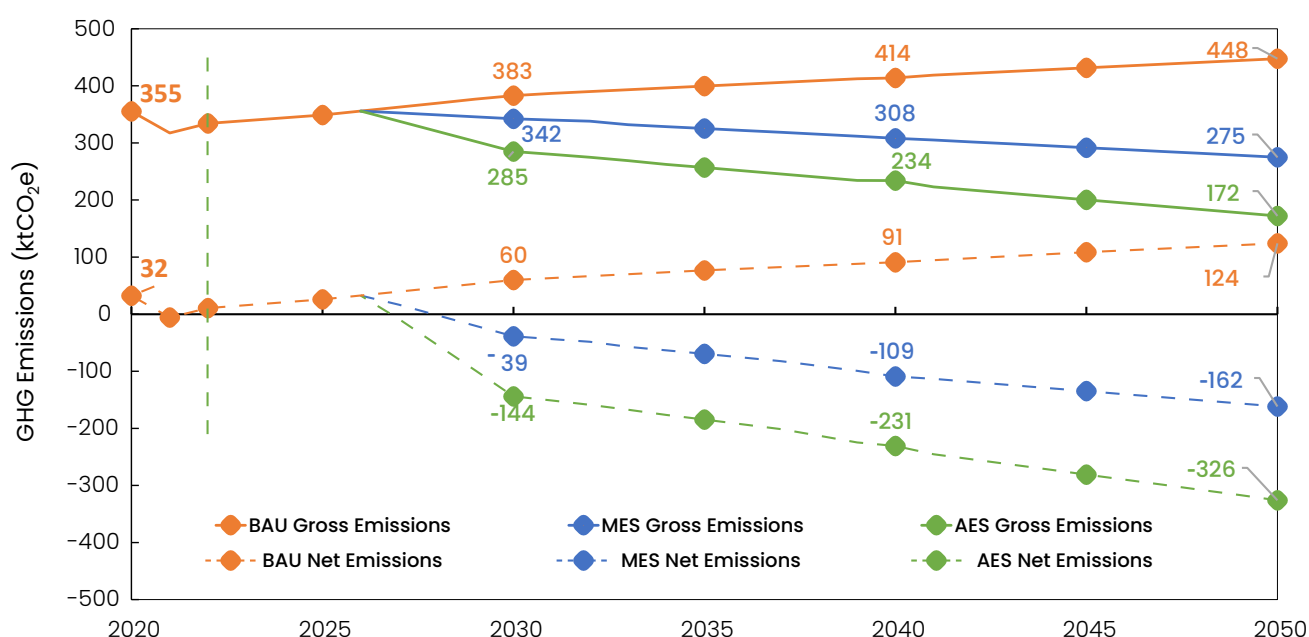


Figure ES2: Economy wide gross and net GHG emissions across the scenarios



Energy sector, especially road transport, is the key to achieve carbon neutrality.

Gross energy sector GHG emissions (excluding IPPU) could grow to 332 ktCO₂e by 2050. In 2022, the total energy emissions amount to 252 ktCO₂e, with the transport sector as the primary contributor at 145 ktCO₂e. By 2050, the transport sector is expected to experience a steady growth, with emissions growing by approximately 30 percent, reaching 189 ktCO₂e by 2050. However, with the decarbonisation measures, the sector's GHG emissions is expected to drop 46 percent to 103 ktCO₂e as compared to the BCS (Figure ES3). Similarly, emissions from the building sector, which account for 31% of remaining energy emissions in 2022 and is expected to continue as the second highest emitter in the energy sector in 2050 too, can be reduced by 65% through adoption of clean cooking and energy efficient solutions.

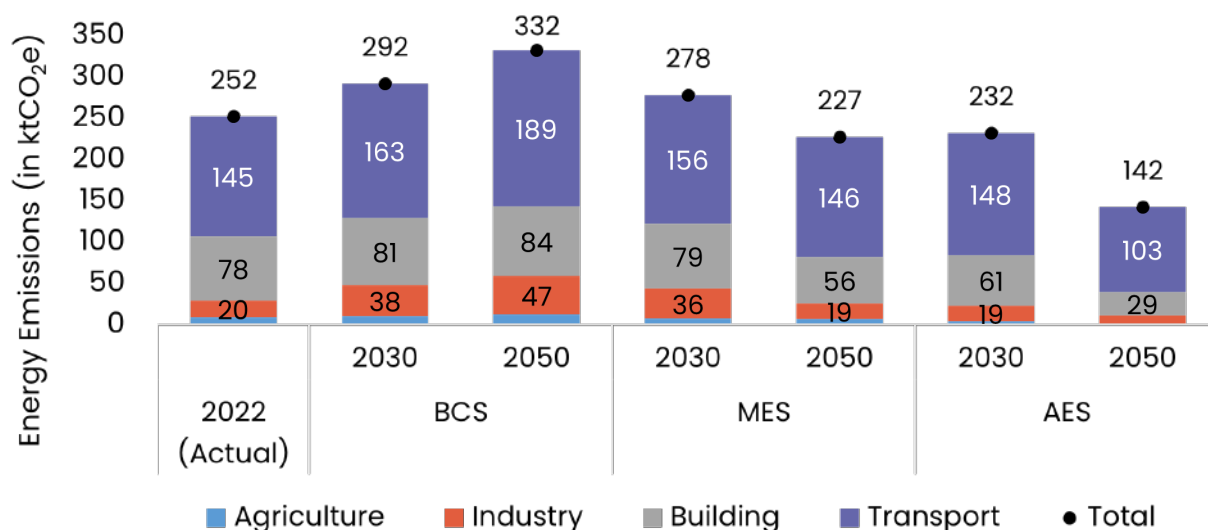


Figure ES3: Total Primary Energy Supply across the scenarios



Electricity consumption is set to grow two-fold with new demand sectors ready to shape electricity mix.

The district produces ~2100 GWh of hydro based clean electricity (2022), which is almost five times its electricity demand. With fuel switching in the transport and cooking sector, the demand for electricity will rise in the future.

In 2022, the domestic sector was the largest electricity consumer, constituting 46 percent of the total consumption at 197 GWh. By 2050, the domestic sector's share is expected to remain the same, as the efficiency gains from appliances are offset by the increased demand from electric cooking. Meanwhile, the transport sector is expected to grow fast during this period, with its share increasing from 4 percent to 17 percent between 2022 and 2050. Overall, the total electricity consumption is expected to almost double between 2022 and 2050 to 865 GWh. This indicates that despite rising electricity demand, hydro generation will be sufficient to meet future needs. Therefore, from an electricity perspective, the district is already carbon neutral and will remain so.

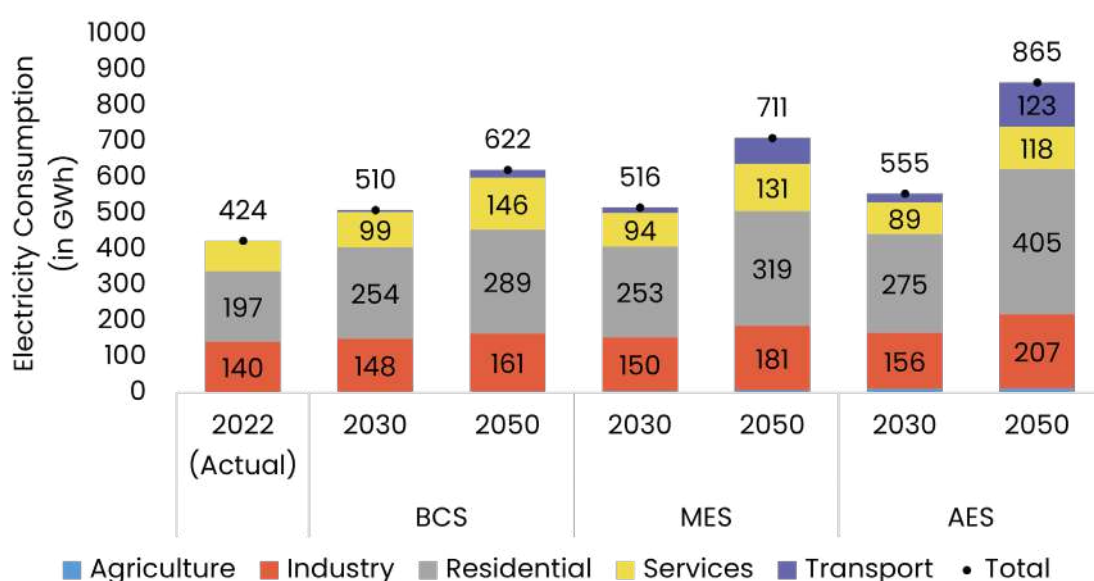


Figure ES4: Electricity Consumption across the scenarios



Energy efficiency and behavioural interventions are set to play a major role in abating additional demand for electricity in the district.

Energy efficiency improvements across residential and commercial sectors will help offset rising electricity demand by 2050. High-efficiency appliances in homes can lead to electricity savings of ~15 percent, while commercial buildings adopting energy-efficient HVAC/heat pumps and lighting can reduce electricity consumption by ~10 percent. Cumulatively, these measures could save ~48 GWh of the projected electricity demand in residential and commercial buildings. By 2050, energy-efficient technologies are expected to be adopted in ~100 percent households, easing pressure from growing electrification in transport and cooking sectors.



Enhancing carbon sequestration through grassland restoration and agro forestry has the potential to bring district's GHG emissions to net negative.

Restoring grasslands, expanding agroforestry, and increasing carbon stock density will play a critical role in achieving net-negative emissions by 2050. Shola forest restoration, along with reforestation and sustainable land management practices, can significantly enhance the district's carbon sequestration potential. An improvement in carbon stock density (CSD) in the range of 4-6 percent could increase CSD from the current rate of 96.22 t/ha to 99.84 t/ha-101.66 t/ha. Achieving these targets could potentially sequester additional 69 ktCO₂e to 104 ktCO₂e in 2050. Whereas, with conversion of 20 percent of 22843 hectares of the total barren/fallow land suitable for agroforestry is projected to sequester approximately 38.7 ktCO₂e by 2050. On the other hand, a 32 percent of the same land area is anticipated to result in a carbon sequestration resulting in around ~63 ktCO₂e by 2050.

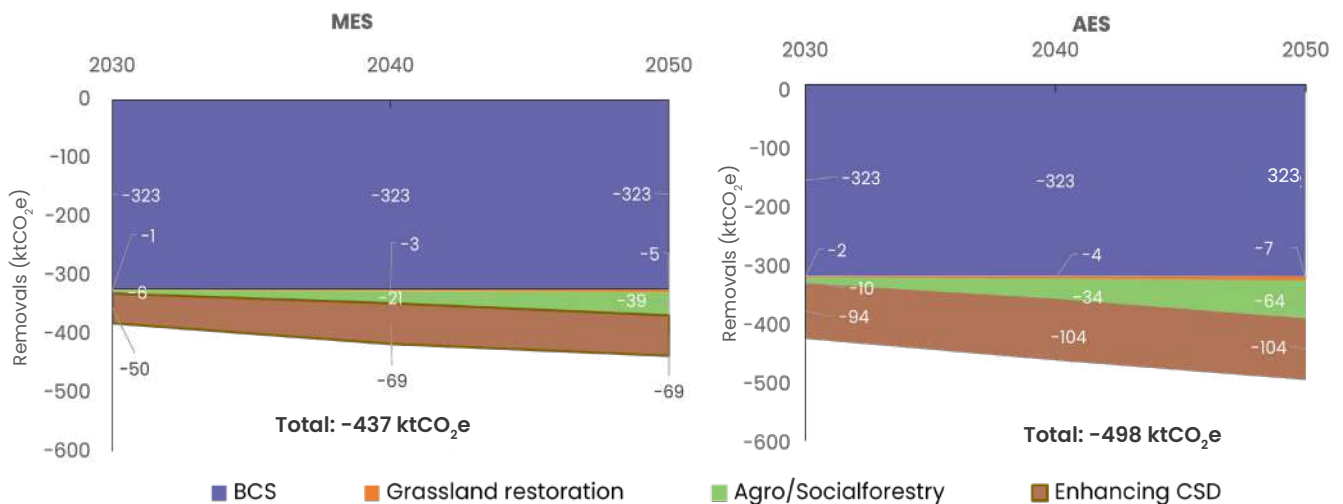


Figure ES5: Sequestration potential through additional interventions

The sectoral interventions for decarbonising Nilgiris and enhancing the carbon sequestration are summarised in the following section.

Why Transform Nilgiris into a Carbon Neutral and Climate Resilient Hub?

-  Preserving Biodiversity
-  Empowering Communities
-  Climate Proofing



DISTRICT HIGHLIGHTS

900 – 2,636 m
Above mean sea level



3,500
Plant species



Indigenous tribes

Toda, Kota, Kurumba, Badaga, Irulas etc.

3 Rivers
Bhavani, Moyar, and Pykara



5520 sq kms
Nilgiris Biosphere Reserve



42,324 Tonnes

Annual tea production (2023-24)



3 key economic sectors

Tourism, horticulture, tea industry

CLIMATE PROFILE



1,609 mm Annual rainfall



1.2°C – 29.7°C
Annual temperature range

0.9°C to 3.5°C

Projected increase in maximum summer temperature by 2090



23% – 46%

Projected increase in south-west monsoon rainfall by 2090



Highly vulnerable to landslides and susceptible to forest fires

GHG EMISSIONS (2022)



Carbon neutral

Already achieved in electricity



334 ktCO₂e gross emissions



43%

Road transport



20%

Residential energy



10%

Domestic wastewater

Key contributors (% of gross emissions)



11 ktCO₂e

Net emissions



(-323) ktCO₂e

Annual sequestration

TRANSFORMATION POTENTIAL



One of the 1st
carbon neutral hubs in India before 2030



276 ktCO₂e

Annual mitigation potential by 2050



(-498) ktCO₂e

Annual sequestration potential by 2050



Enhanced Forest Cover
Leading to minimised landslides risk



Carbon Credit-based Financing



Sustainable Tourism
Attracting global recognition

Low-Carbon Interventions and Ecosystem-Livelihood Co-benefits



Blue-Green Ecosystem

-498 ktCO₂e*

Intervention

- Shola restoration
- Enhance the carbon stock density of existing forest cover
- Agroforestry in waste/fallow lands

Resilience & Co-benefits

- Reduces flash floods, landslides, fires
- Improves air, water & soil

Economics and Livelihood Improvement

- Supports eco-tourism & green jobs
- Reduced loss and damage
- Empowers indigenous communities
- Builds community stewardship



Agri and Tea Industry

103 ktCO₂e*

Intervention

- Replace 80% fuelwood heaters in tea industry
- Shift 2,000 diesel pumps to solar by 2030
- Use 75% organic fertiliser and 25% nano urea

Resilience & Co-benefits

- Boosts energy access, health and savings
- Increases soil and crop resilience
- Improves air, water and soil

Economics and Livelihood Improvement

- Improved efficiency and operational performance
- Minimises supply chain disruption
- Builds resilient farming community



Low-Carbon Mobility

80 ktCO₂e* + unquantified (PBS)

Intervention

- Transition to EVs (2W, 3W, 4W, buses)
- NMT and PBS infrastructure

Resilience & Co-benefits

- Resilient transport access
- Cooler cities
- Cleaner air

Economics and Livelihood Improvement

- Boosts ecotourism
- Green jobs, especially for women
- Better health, last-mile access

*The values refers to mitigation potential

NMT: Non-motorised transport; PBS: Public bike sharing

What Does Climate-Resilient Development Deliver?



Enhanced adaptive capacity of the town/community



Improved thermal comfort and climate-resilient living conditions



Reduced health risks from heat, waterborne, and vector diseases



Enhanced community capacity to withstand climate shocks



Inclusive action benefiting indigenous and vulnerable groups



Ecosystem restoration reducing disaster risks (e.g., landslides)



Lowered human-wildlife conflict through habitat-sensitive planning



Bankable green projects | Access to global climate finance | Green jobs | Livelihood security | Savings from energy transition and efficiency | Offset infrastructure expansion

NILGIRIS DECARBONISATION ACTION PLAN

Nilgiris has the potential to become carbon neutral well before 2030

The gross GHG emissions are expected to reach 383 ktCO₂e by 2030, and subsequently 448 ktCO₂e by 2050 from current level of 334 ktCO₂e in 2022. However, the net emissions, considering the sequestration, in 2022 are 11 ktCO₂e. It could further achieve a net negative of 362 ktCO₂e under AES and 162 ktCO₂e under MES by 2050 – serving as a model and catalyst for other districts in Tamil Nadu.

AES – Aggressive Effort Scenario | MES – Moderate Effort Scenario



ELECTRICITY



From the perspective of electricity generation and consumption, **Nilgiris is already carbon neutral**, its **hydroelectric** capacity stands at **830 MW generating ~2200 GWh** electricity annually.



Electricity consumption expected to rise to **711-865 GWh in 2050**, growing twofold from the current level. However, the **generation from the clean sources will remain higher than the consumption**.



Holistic assessment of **solar rooftop, floating solar**, and other **DRE sources** needed on priority.

Electrification of Road Transport

EV penetration as % of new vehicle sales



Two/three-wheelers
70% by 2030
100% by 2050



Four-wheelers
30% by 2030
70% by 2050



Buses
20% by 2030
50% by 2050



86 ktCO₂e
(19% of gross emissions)
GHG emissions can be abated by 2050 through electrification.



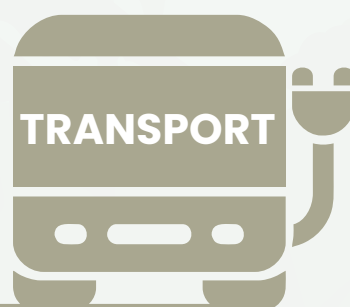
Prioritise addition of **intra-district E-buses** to cater tourist demand.



Non-motorised transport, build cycle lanes, public bike-sharing, and pedestrian-friendly walking lanes.



Public charging stations, set up 5 charging stations on petrol pumps, and another 5 in optimal positions near bus depots.



Electrification of Pumping and Agro Machinery



Replace 100% of diesel pumps i.e. **~1,120 with decentralised solar pumps** under the PM KUSUM by 2030 and a total of 2000 solar pumps by 2050.



Reduce diesel use in farming; exploring the possibility of replacing diesel tractors and tillers with EVs in a long term.



~11 ktCO₂e
(2% of gross emissions)

GHG emissions can be abated by switching to solar pumps and electric tractors by 2050.



Fertiliser Shift

Replacing **75%** of nitrogen fertiliser and urea with **organic fertiliser and nano-urea** by 2050.



Agriculture soils emission abated by **54 ktCO₂e** (12% of gross emissions).





Promoting Social & Agroforestry in Barren/Fallow Lands

Repurposing **7276 ha** of barren/fallow land for horticulture and agro/social forestry can abate **~10 ktCO₂e by 2030 and ~64 ktCO₂e by 2050**.



Enhancing Carbon Stock Density

Enhancing the carbon stock density (CSD) by **6%, from ~96 t/ha to 102 t/ha (2015 baseline)**, can sequester **94 ktCO₂e annually by 2030 and 104 ktCO₂e by 2050** through reforestation and afforestation and implementing sustainable forest management practices.



497 ktCO₂e

(112% of gross emissions by 2050)



Restoration of Shola Grassland

in degraded grasslands & additionally **56.4 km² of cultivable wasteland** by reviving resilient native grass species that thrive amidst invasive pressures can sequester **2 ktCO₂e by 2030 and 7 ktCO₂e by 2050**.
Eg. *Andropogon lividus* and *Eulalia phaeothrix*



Efficiency and Conservation

Mandate retrofits for hotels and public buildings, including **energy-efficient heating, electrification of firewood-based heating and LED lighting**.



Diesel Generator Phase-out

Transition to hybrid solar-battery systems in hotels and commercial establishments **can save ~5.2 TMT diesel**.



COMMERCIAL BUILDINGS



Energy Efficiency

Promote **5-star appliances with govt backed schemes like EEFP* and SEEP****. High-efficiency appliances and lighting in homes and commercial buildings can save **~48 GWh electricity in buildings**.



Clean Cooking Transition

Shift **~50% of households** cooking from LPG to induction cookstoves; and **100% cooking demand in commercial** hotels and institutions.



55 ktCO₂e (12% of gross emissions) + 279 ktCO₂e (Scope 2)
GHG emissions in buildings sector by 2050.



RESIDENTIAL BUILDINGS

*EEFP — Energy Efficiency Financing Platform
**SEEP — Super Efficient Equipment Programme

Fuel Switching



Shifting from fuel oil/firewood to electricity can help abate **~38 ktCO₂e (8% of gross emissions)** industry GHG emissions by 2050.



By 2030

Rooftop solar and electric air heaters at Indcoserve's Kaikatty Tea Factory.

By 2050

Fully decarbonise tea production with electric air heaters & captive solar.



Mandate **zero discharge policy** in all industrial areas.



INDUSTRY

Waste Management



Improved waste treatment can help abate **32 ktCO₂e (7% of gross emissions)** GHG emissions by 2050.



45 MLD centralised wastewater treatment is recommended for urban centers, twin-pit septic tanks and **FSTPs** are recommended at gram panchayat clusters for rural areas.

WASTE



1. Context, Methodology, and Scenario Framework

At the 26th Conference of Parties (COP 26) in November 2021, India made a bold commitment of achieving net-zero greenhouse gas emissions by 2070, signalling its strong resolve to combat climate change. This ambitious pledge marks a significant milestone in India's journey towards sustainable development and highlights the country's determination to play a leading role in the global effort to reduce carbon emissions.

Complementing the national agenda, it is vital to acknowledge the importance of sub-national entities. As India forges ahead with its national decarbonisation plan, active engagement of states and regions becomes paramount for realising the broader vision of a carbon-neutral and resilient India.

Further, the state of Tamil Nadu has emerged as a leader in mitigating carbon emissions through various initiatives. In this regard, the Government of Tamil Nadu has established the Tamil Nadu Green Climate Company (TNGCC), with the intention to bolster the state's endeavours in advancing renewable energy, sustainable infrastructure, sustainable agriculture, forest management and conservation, as well as fostering resilience and adaptation to climate impacts.

TNGCC has not only embraced a broad macroeconomic approach to attain carbon neutrality at the state level but has also adopted a bottom-up strategy by formalising a plan to decarbonise districts and towns in Tamil Nadu. The Nilgiris district has been identified as a key region in Tamil Nadu's efforts to achieve carbon neutrality.

In support of this initiative, the Vasudha Foundation, in collaboration with TNGCC, has developed a targeted decarbonisation strategy for the Nilgiris district. This comprehensive study analyses current and historical emissions, evaluates the region's energy mix, forecasts future energy trends, and proposes a comprehensive decarbonisation plan across various scenarios under consideration.

Methodology Adopted

This study proposes a fourfold approach for preparing the decarbonisation plan for the Nilgiris District. This approach is as follows:

 Climate Variability Analysis and Projections	Historical climate data and climate models under RCP 4.5 and RCP 8.5 scenarios are used to project future changes in rainfall, temperatures, and heatwaves.
 Historical GHG Emission Inventory	To determine the historical greenhouse gas (GHG) emissions of the district, the methodology outlined by the Intergovernmental Panel on Climate Change (IPCC) for GHG emission inventories is adopted. This approach typically involves collating data from various sectors contributing to emissions, such as energy, agriculture, forestry, and waste, and applying emission factors and activity data to calculate overall GHG emissions.
 Energy Sector and Other Sectors Demand and Emissions Projection	A bottom-up energy system model was used, projecting energy demand and emissions from 2024 to 2050, with a five-year timestep. The model illustrates the transformation of primary energy along the energy supply chain to meet energy service demand and the final energy consumed by the end-user. The sectors covered are residential, services, agriculture, transportation and industry. Apart from these, emissions from rice cultivation, livestock, waste and other land uses are estimated. The potential for additional carbon sequestration from forestry is also considered.
 Sectoral GHG Emissions Abatement and Sequestration Potential Assessment	To enhance sequestration potential, a comprehensive methodology has been adopted, involving several key strategies. The scope for extensive afforestation and reforestation, with a focus on native and fast-growing tree species to maximise carbon uptake, and agroforestry practices has also been assessed. Furthermore, scenarios have been explored to increase the carbon stock density of existing forests.



Scenario Framework

The scenarios analysed in this study have been designed with a view to the different operational and technological parameters. These parameters vary depending on system-level efficiency, fuel switching, behavioural changes, improving existing forest cover, waste management practices and land utilisation etc. The studied scenarios in this report are:

1. Baseline Case Scenario (BCS)

The BCS Scenario depicts energy and non-energy sector demand and supply growth in line with current state policies and historical trajectories, where applicable. In this scenario, improvements in energy efficiency remain constant at current levels throughout the projection period. Similarly, limited potential for fuel switching persists, primarily through the electrification of road transport, supported by initiatives like FAME and state EV schemes, while households and commercial establishments continue to use LPG and biomass for cooking. For other sectors, sequestration remains at current levels, and households continue to use existing practices in waste management. This scenario will be used as the reference scenario upon which the decarbonisation scenario will be built, as discussed next.

2. Moderate Effort Scenario (MES)

MES illustrates the extent to which current national policies and announced state government targets can achieve emissions abatement (i.e. India's NDC). This scenario makes relatively moderate assumptions on various sectoral emission abatement interventions. For non-energy sectors, the scenario outlines a practically feasible approach with moderate decarbonisation targets for categories such as waste treatment and fertilisers, along with exploring the scope for enhancing existing carbon sequestration in the district.

3. Aggressive Effort Scenario (AES)

The AES scenario presents an aggressive outlook to decarbonise the district by 2050 while ensuring energy security in the region. Although the interventions guarantee a significant reduction in the emissions trajectory through the energy sector alone, sequestration, as well as additional ambitions, will ensure compliance with all overall decarbonisation targets. The decarbonisation efforts are achieved through widespread electrification of end-use demand. For non-energy sectors, the AES follows ambitious strategies regarding waste treatment, fertiliser use, and sequestration efforts to ensure faster reduction in GHG emissions.

Table 1: Assumptions considered under this study

Sector	Sub-Sector disaggregation	Demand Driver	Scenario-BCS	MES	AES
Agriculture	Irrigation	Annual increase in water consumption* and fuel demand	•2022 shares of electrified, diesel, and solar pump sets remain unchanged through 2050.	Conversion of 35% of diesel pumpsets to off-grid solar pumps by 2030	Conversion of 100% of diesel pumpsets to off-grid solar pumps by 2030
Buildings (Residential, Commercial, and Cooking)	Residential Appliances & Lighting	GSDP growth leading to higher spend capacities, Higher temperature led space cooling needs	•Current level of EE to continue till 2050 •Stock out of Conventional Lighting by 2030	3 Star Appliances to cut down energy demand by 3-4% by 2050	5 Star Appliances to cut down energy demand by 7-8% by 2050
		GSDP Growth, Population Growth	LPG as a major fuel for cookstoves, only 2% cookstoves electrified by 2050	Shift in composition to LPG (60%), electricity (33%) and biomass (7%)	Shift in composition to LPG (37%) and electricity (63%)
	Commercial Buildings, Public Lighting, Miscellaneous Services	Commercial Development in the District, leading to increase in electricity and fuel consumption	Electricity consumption in commercial buildings and public lighting to increase by 2.5% and 3% respectively by 2050	Replacement of street lights with LED by 2030	Replacement of street lights with LED by 2030
Transport	Road Vehicles	Annual growth in vehicle demand*	Partial electrification of 2W, 3W, 4W, buses and HGVs	•75-80% electrification of 2W and 3W •35-50% electrification of buses and 4-W •10% electrification of trucks	•100% electrification of 2W and 3W •70% electrification of 4-W •50% electrification of buses and 20% of trucks
Industry	Tea, Horticulture, others	Annual industrial growth* leading to increased energy demand	Current growth and emission rates from fuel consumption to continue till 2050	Energy Efficiency and 80% electrification of heating processes	

Carbon sequestration			The current levels of forest cover 1559 sq.km and carbon stock density 96.22 t/Ha is maintained	•Repurposing 20 percent of barren/fallow lands (22843 ha) to horti culture, agro/ social forestry •Enhancing Carbon Stock Density by 4 percent from 96.22 t/ha to 99.84 t/ha •Restoration of grass-land in the existing degraded area and additionally in 42.3 sq km land classified as cultivable wasteland	•Repurposing 32 percent of barren/fallow lands (22843 ha) to horti culture, agro/ social forestry •Enhancing Carbon Stock Density by 6 percent from 96.22 t/ha to 101.66 t/ha •Restoration of grass-land in the existing degraded area and additionally in 56.37 sq km land classified as cultivable wasteland
	Waste	Domestic wastewater	Current growth	100 percent treatment by 2035	100 percent treatment by 2030
Agriculture		Agriculture Soils	Current growth	Substituting nitrogen for tiliser and urea with 50 percent organic fertiliser and 50 percent nano- urea by 2050	Substituting nitrogen fertiliser and urea with 75 percent organic fertiliser and 25 percent nano- urea by 2050
		Livestock	Growing market for milk and meat	60% manure managed to avoid methane emissions,Balanced rationing implemented for 60%; improved feed supplements for 45% cattle by 2050	90% manure managed to avoid methane emissions,Balanced rationing implemented for 90%; improved feed supplements for 75% cattle by 2050

2. District Profile

2.1 The Nilgiris

Nilgiris District, Tamil Nadu

The Nilgiris is one of Tamil Nadu's 38 districts, and it was established in February 1882. Located at the confluence of the Eastern Ghats and the Western Ghats, it is rich in biodiversity and supports a wide variety of flora and fauna. The district shares its administrative boundaries with Kerala and Karnataka and lies at an elevation between 900 and 2,636 metres above mean sea level.

The climate in the region is temperate to subtropical, with a topography characterised by rolling and steep terrain. About 60 percent of the cultivable land falls under the slope ranging from 10 percent to 33 percent.⁸ The average annual rainfall varies between 950 mm to 1550 mm.⁹



Figure 1: Nilgiris district map

The district is situated in the Hill and High Altitude Agro-Climatic Zone,¹⁰ known for its hilly terrain, lush greenery, and numerous peaks. The highest peak in South India, the 'Doddabetta', with an altitude of 2,595 metres, is located within this district.¹¹ Other prominent hills in this district include Elk Hill, Devarshola peak, Hulical hill and Cairn hill. Additionally, there are many streams and tributaries originating from the district, forming an important catchment for the adjoining plains of Tamil Nadu. The Nilgiris district is also a biodiversity-rich zone, encompassing important habitats such as the Shola forest and moist evergreen forests of the Nilgiris Biosphere Reserve, of which the district forms part. The Nilgiris Biosphere Reserve also encompasses the Mudumalai Wildlife Sanctuary and the Bandipur National Park.

The major economic activities of the Nilgiris district are tourism and tea plantations, along with cottage industries such as cheese and chocolate production. The estimated Gross District Domestic Product (at Constant prices) for the year 2022-23 was approximately ₹9,51,212 Lakhs, constituting about 0.65% of the State's economy.¹²

According to the Destination Master Plan developed for the Nilgiris, tea cultivation covers nearly 70 percent of the total cultivated area.¹³ Approximately two lakh workers are engaged in tea cultivation and production in the district. Tourism is another significant contributor to the district's economy, providing employment to locals in sectors such as hospitality (hotels, guesthouses, homestays, and lodges), dining (restaurants, food stalls, bakeries, and coffee shops), among others.¹⁴

Location  Northwestern Tamil Nadu	Latitude  North Latitude between 11° 30' 00".12 and 11° 30' 00".42	Longitude  East Longitude between 76° 29' 52".55 and 76° 36' 00".21		
 Geographical area in sq.km. 2,544.85	 Revenue Divisions 03	 Revenue Villages 54	 Municipalities 04	
Blocks  4 (Udagamandalam, Coonoor, Nelliylam, Gudalur)	Gross Domestic Product at Constant Prices, in 2022-23 (in lakhs)  9,51,212	Total Population (Census 2011)  7,35,394		
Population Density  287	Decadal Population Growth (2001-2011)  3.55%	Projected Population (2021)  7,09,713 (As per District Statistical Handbook 2022-23)	Urban Population (Census 2011)  4,35,655	
Urban Population  59.24%	Rural Population (Census 2011)  2,99,739	Rural Population  40.75%	Sex Ratio (Census 2011)  1,042	Literacy Rate (Census 2011)  85.65%

Source¹⁵

2.2 Sectoral Overview of the Nilgiris District

2.2.1 Power and Energy Profile



Generation

The current installed power capacity in the Nilgiris district is 834 MW, comprising large and small hydro power plants. The major hydroelectric power projects in Nilgiris District are the Kundah power project, Moyar Power House, Pykara Hydroelectric Power Project, and Parsons Valley Hydroelectric Power Project, amongst others. The total electricity generation from all the power plants situated in the district was 2126 GWh (MU) in 2022.



Electricity Consumption Patterns

The total electricity consumption in the Nilgiris district in 2022 was 425 MU. The domestic sector accounted for the largest share of electricity consumption, amounting to 198 MU, which made up 47 percent of the total electricity consumption. This was followed by the Industries & HT services with total consumption of 141 MU and a share of 33 percent of the total electricity consumption. Commercial sector consumed approximately 58 MU, representing 14 percent of the total electricity consumption. Public lighting and agriculture consumed 26 MU and 2 MU respectively, and accounted for 6 percent and less than 1 percent respectively in the total electricity consumed in 2022 (Figure 2).

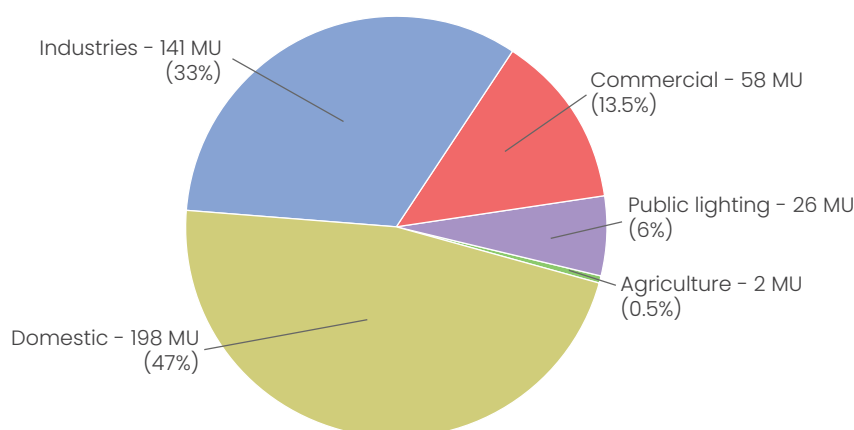


Figure 2 : Sector-wise power consumption distribution of Nilgiris district (2021-22), Source: TNEB

2.2.2 Transport and Other Infrastructure



Road Connectivity

The Nilgiris district has a total road length of 3110 kms, of which 2761 kms is surfaced road and around 349 kms is unsurfaced road.¹⁶ All taluks in the district are connected with major district roads. The village roads are maintained by the Panchayat Union.¹⁷ The district also has Nagapattinam - Gudalur National Highway passing through it.



Rail Connectivity

The iconic Nilgiris Mountain Railway, a UNESCO recognised Heritage Railway, connects Mettupalayam (Coimbatore district) to Ooty (Nilgiris district), covering a total distance of 46 kilometres and many towns of the Nilgiris district.

2.2.3 Land and Other Natural Resources Profile

Nilgiris is a resource rich district, with ~60% of land under forest area. Between 2013 and 2023, very dense and open forests have marginally decreased, while there has been a decline in area under moderate forests. This could be due to reduction of evasive species. At the same time, build-up land has grown by ~6%.

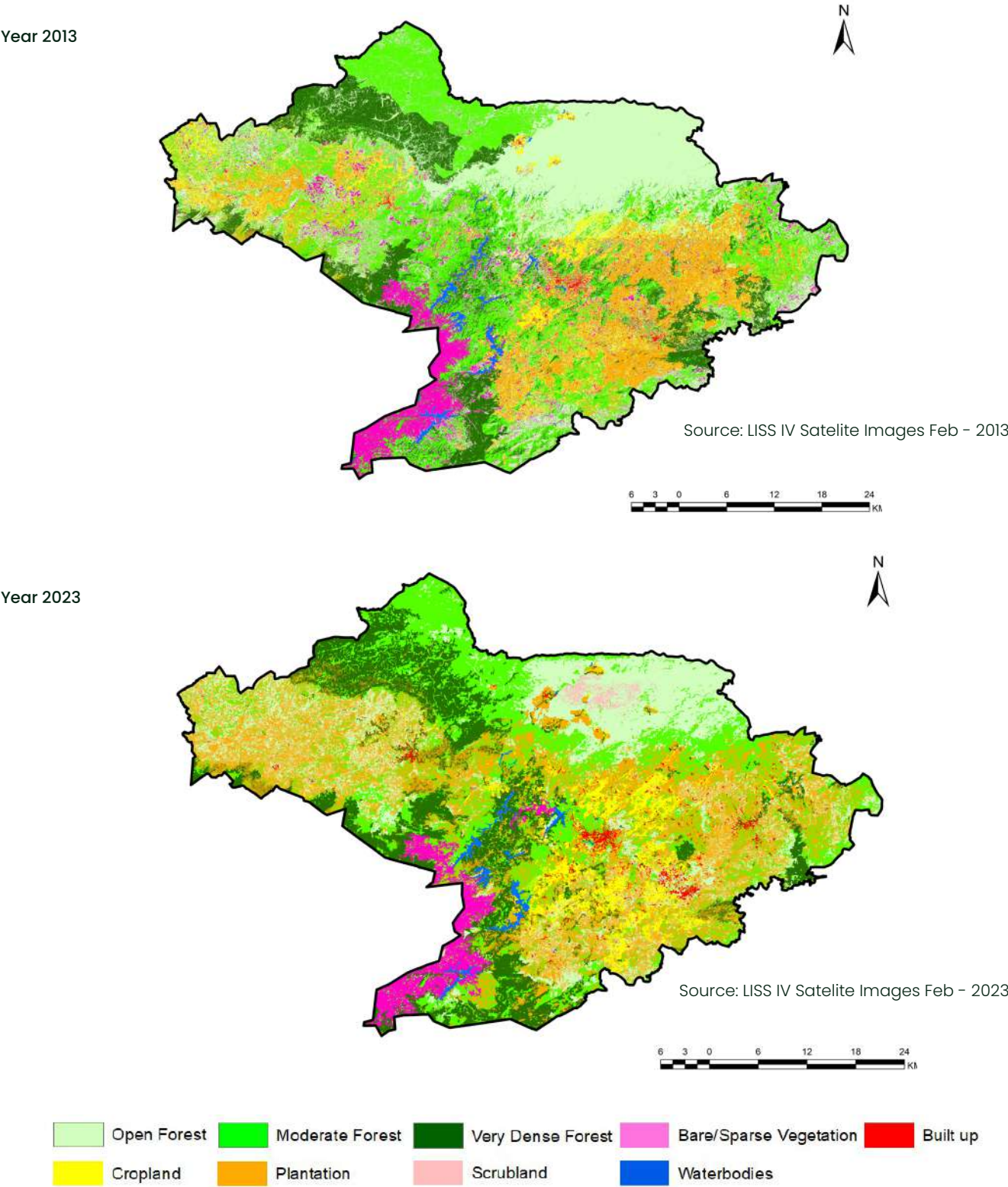


Figure 3: Land use change map between 2013 and 2023

Table 2: Land use change statistics between 2013 and 2023

Land use/ land cover categories (sq km)	Bare/ Sparse Vegetation	Built- up Land	Crop- land	Mod- erate Forest	Open Forest	Planta- tion	Scrub- land	Very Dense Forest	Water Bodies
Year 2013	86.2	31.3	84.3	657.1	566	698	27.4	380.3	19.5
Year 2023	102.4	33.1	94.1	600.3	573	704.8	30.8	383.7	27.9
Change (%)	18.79	5.75	11.63	-8.64	1.24	0.97	12.41	0.89	43.08

Table 3: Land use data of Nilgiris District (2022-23)

Particulars		Nilgiris District (area in sq.km.) ¹⁸
Total Geographical Area		2544.85
Forests		1425.76
Not Available for Cultivation	Area Under Non-Agricultural Uses	99.87
	Barren and Unculturable Land	34.02
	Total	133.89
Other Uncultivated Land Excluding Fallow Land	Permanent Pasture and Other Grazing Land	50.78
	Land Under Misc. Tree Crops and Groves not Included in Net Area Sown	46.82
	Culturable Waste Land	56.38
	Total	153.97
Fallow Land	Fallow Lands Other Than Current Fallows	73.25
	Current Fallow	35.31
	Total	108.56
Net Area Sown		722.65



Forest Land

The total forest cover in the Nilgiris district was 1,514.19 sq. km in 2016. By 2023, the total forest cover increased to 1559.09 sq. km.¹⁹ (Figure 4).

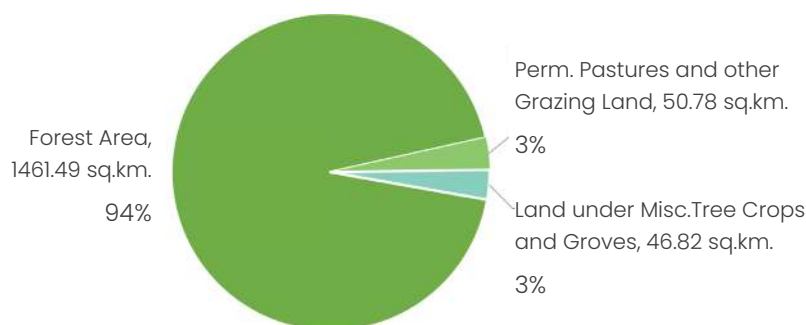


Figure 4: Composition of forest cover in Nilgiris district (Source : District Statistical Handbook Nilgiris District 2022-23)



Habitat

As per the 2011 Census, around 59.25% of the population in Nilgiris district resides in urban areas, while the remaining 40.75% resides in rural areas. The district's Land Use and Land Cover (LULC) maps for the years 2002 and 2023 show that urbanisation has increased by 138 percent, from 14.6 sq.km to 34.8 sq.km, with most of this conversion occurring from forest and agricultural lands.



Wetlands & Biodiversity

Wetlands in the district cover around 31.27 sq.km, accounting 1.27% of the district's total land area.²⁰

The Nilgiris Biosphere Reserve is the first biosphere reserve in India, designated by UNESCO in 1986.²¹ It covers an area of over 5,000 square kilometres in the Western Ghats and Nilgiris Hills of South India.²² The district is home to a rich diversity of flora and fauna. The area has various types of forests and grasslands and about 3,500 kinds of flowers, 1500 of which are endemic to this region. The animals here include over 100 types of mammals, 550 kinds of birds, and many other creatures such as reptiles and butterflies. The region is home to both endangered animals like the Nilgiri Tahr and tigers, and threatened species like elephants and Indian bison.²³



Water Resources

The entire hilly terrain of the district forms part of the Cauvery basin. Numerous streams originating from hill slopes have formed rivers in the deep valleys. Several reservoirs have been formed in the district to harness surface water. Water from these reservoirs is used for both drinking purposes and power generation.²⁴ In 2021-22, the pre-monsoon water levels in the district ranged from 2 to 5 metres below ground level (mbgl), while post-monsoon water levels ranged from 0 to 2 mbgl.²⁵

2.2.4 Other Economic Activities

As of 2021-22, the district had approximately 3,500 Micro, Small and Medium Enterprises (MSMEs), predominantly in tea processing, chocolate making and other agro-based small and cottage industries. Based on 2020-21 data, these MSMEs together offered employment opportunities to at least 11,417 people. The district does not have any large industrial activities as such, with the exception of Needle Industry India Pvt. Ltd and the Ministry of Defence-run Cordite factory.

Other economic activities include horticulture, sericulture and floriculture. Major plantation crops in the district include tea, coffee and arecanut. Vegetables such as carrots and potatoes, as well as spices and condiments like pepper, cardamom, garlic and ginger are also cultivated here.

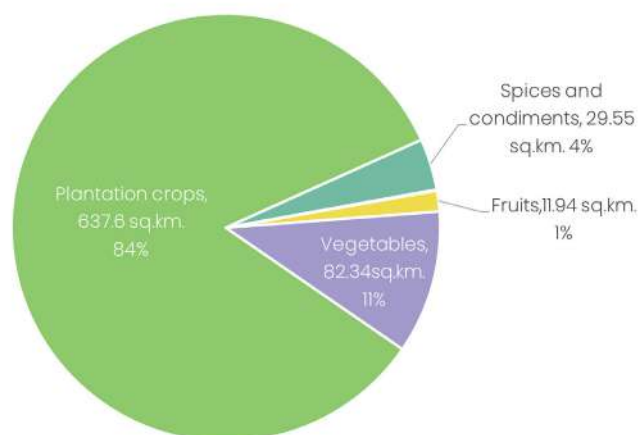


Figure 5: Distribution of agriculture crop wise area of Nilgiris district (2021-22)²⁶

2.2.5 Waste Sector

In 2023, the total solid waste generated by the 16 Urban Local Bodies (ULBs) in the district was 101 tonnes per day (TPD). The solid waste generated in the district is fully collected and processed across the ULBs. Of the total waste processed in the district, dry waste amounts to 45 TPD, wet waste amounts to 40 TPD, sanitary waste amounts to 14 TPD and domestic hazardous waste amounts to around two tonnes per day.²⁷

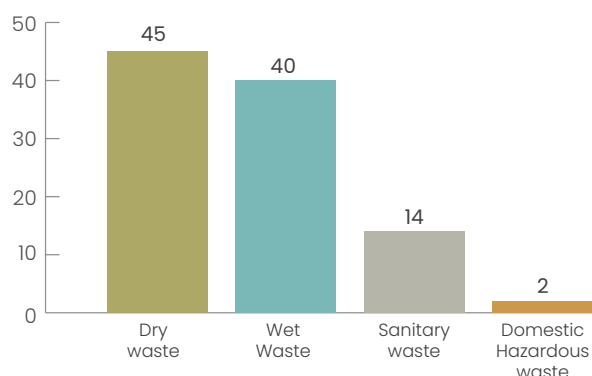


Figure 6: Type of waste processed in Nilgiris district (2023)

The Nilgiris district has door-to-door waste collection services provided across its 301 wards and currently source segregation of waste is practiced in 296 of these wards. The district banned 'one-time use and throw' plastic in 2018. Awareness activities, including campaigns like "Meendum Manjappai" are organised regularly to curb plastic usage wherever possible. Water ATMs have been installed at prime locations as an alternative to the banned plastic water bottles.²⁸

Fifteen out of the 16 ULBs in the district have been declared Open Defecation Free (ODF+).²⁹ There are two operational Sewage Treatment Plants (STP) in the district with a total installed capacity of 7 Million Liters Per Day (MLD).³⁰

2.2.6 Tourism

The Nilgiris district hosts three hill stations: Ooty, Coonoor, and Kotagiri. The principal town and district headquarters of the area is Ootacamund, also known as Ooty or Udhagamandalam. Referred to as the 'Queen of Hill Stations', Ooty attracts around 2.5 million visitors annually and is recognised as a prime tourist destination in India, particularly in South India. The district has several homestays and about 164 hotels across its four municipalities. Between 2015 and 2023, the district experienced a 20 percent increase in tourist footfall, driven mainly by domestic tourists.



3. Climate Vulnerability, Climate Variability and Projections

The climate of Nilgiris is classified as temperate to subtropical. The mean maximum summer temperatures (March–April–May) ranges from 30°C to 34°C, with April being the hottest month in the district. The winter temperature (December–January–February) ranges from 14°C to 19°C, with January being the coldest month. The maximum rainfall occurs during the southwest monsoon period³¹ (June to September), with a mean rainfall of 815 mm (1951–2020). The mean rainfall during the northeast monsoon season (October to December) is around 380 mm. This chapter focuses on historical climate information (1986–2005) and projects climate for a future period using global climate models. Precipitation and temperature are used as the key climate variables for this analysis. The simulations of precipitation and temperature have been used for 1986 to 2005 (historical period) while projections have been considered over four different epochs 2021–2040 (2030s), 2041–2060 (2050s), 2061–2080 (2070s) and 2081–2100 (2090s) under medium (RCP4.5) and high (RCP8.5) emission scenarios³².

3.1 Temperature

Variability

Maximum Temperature

- The year-to-year variability in maximum temperature in the summer months (March–April–May) shows an increasing tendency, which has accelerated in the last decade 2011–2020 (Figure 7).
- The mean percentage of warm days shows a significant increasing trend (Figure 8).

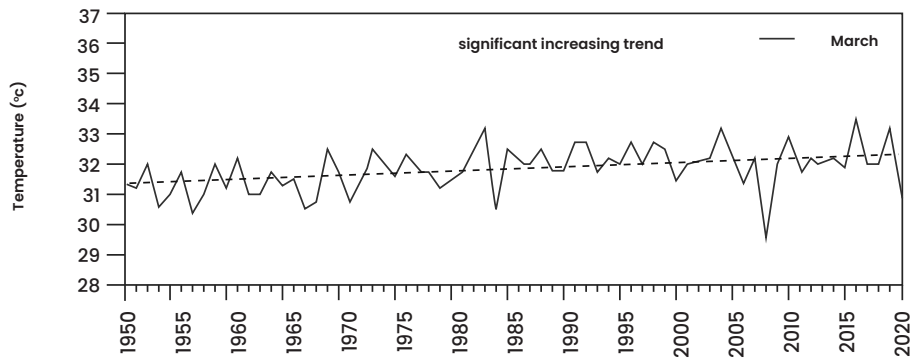


Figure 7: Inter annual variability of maximum temperature (°C) over Nilgiris for 1951-2020

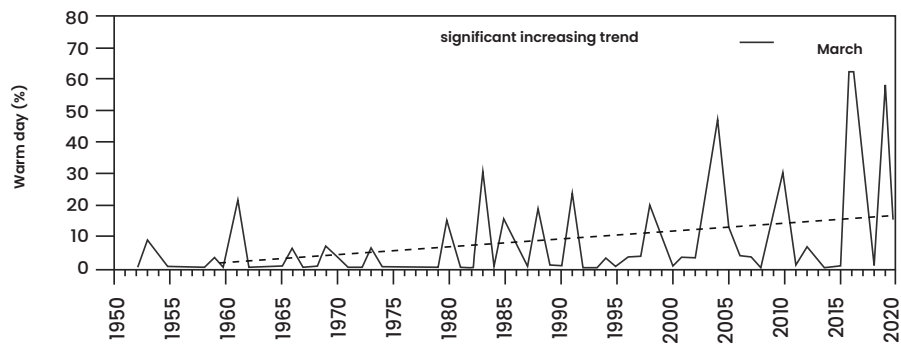


Figure 8: Inter annual variability of warm days over Nilgiris for 1951-2020

Minimum Temperature

- The year-to-year variability in minimum temperature in the winter months (December-January-February) indicates increase in the mean minimum temperature over the period 1951-2020. However, there is no significant trend (Figure 9).
- The mean percentage of cold days has decreased in recent decades (Figure 10).

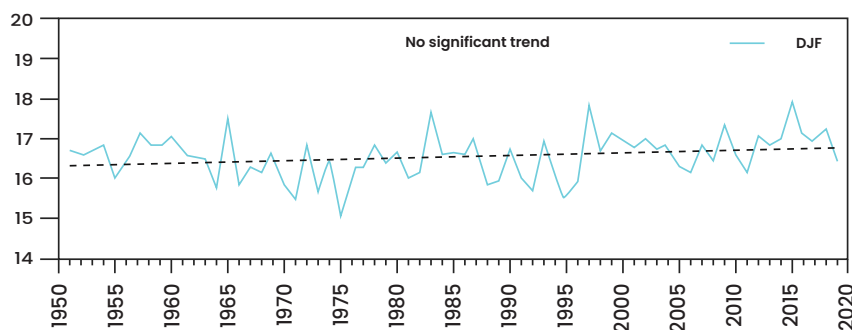


Figure 9: Inter annual variability of minimum temperature (°C) over Nilgiris for 1951-2020

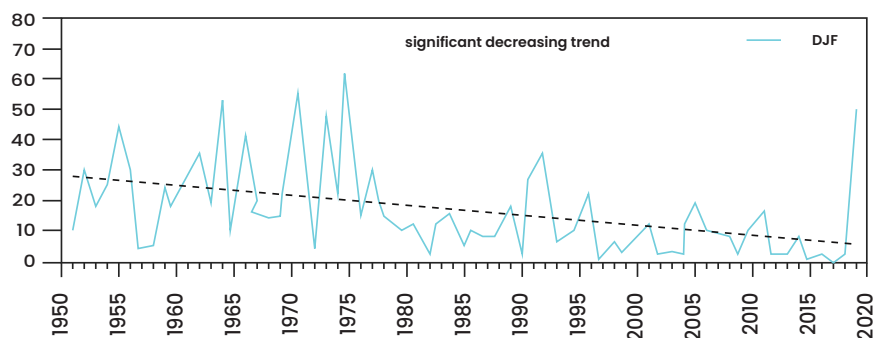


Figure 10: Inter annual variability of cold days over Nilgiris for 1951-2020

Projections

Analysis has been carried out for projected changes in maximum and minimum temperatures on a monthly scale during the summertime (MAM) and wintertime (DJF), respectively.

Maximum Temperature

- The projections for maximum temperatures may increase by 0.8°C – 1.7°C under RCP4.5 and 0.9°C – 3.5°C under RCP8.5 scenarios (Figure 11)*.

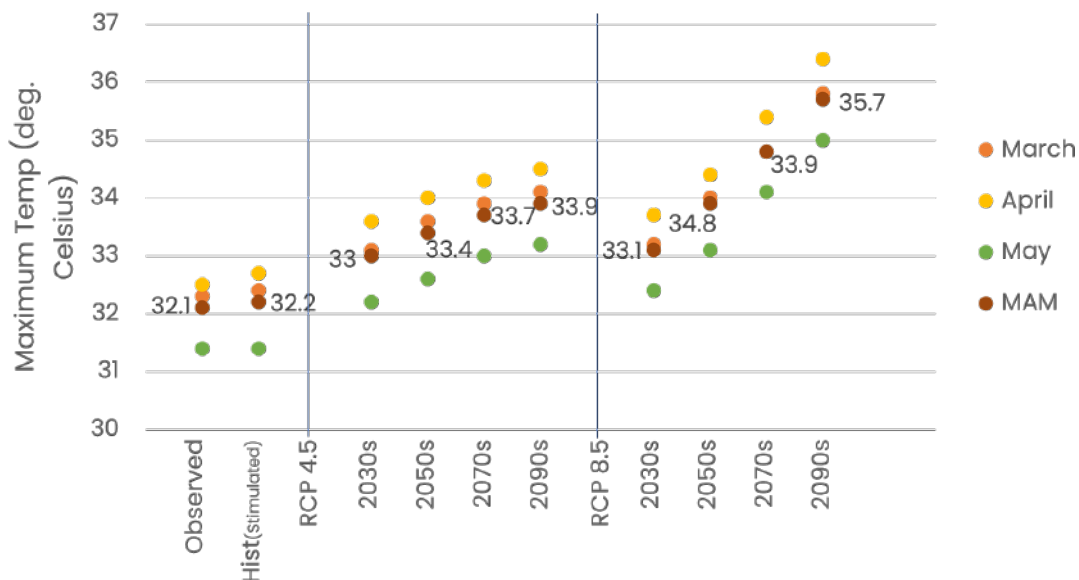


Figure 11: Observed, simulated, and projected monthly and seasonal maximum temperature, Nilgiris district

(The change in maximum temperature is based on MAM, which is observed to be 32.2°C under historical estimates, 33–33.9°C under RCP4.5, and 33.1–35.7°C under RCP8.5)

- The percentage of warm days is projected to increase by the end of the century compared to the present climate (Figure 12).

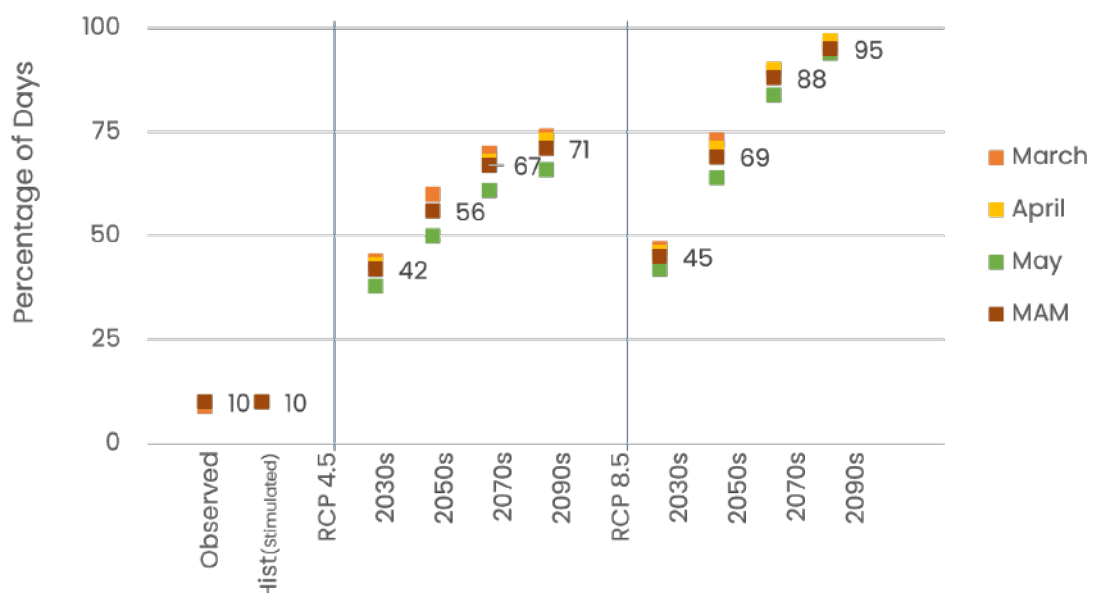


Figure 12: Observed, Simulated, and Projected percentage of warm days, Nilgiris district

- The HWDI³³ is expected to increase by 0–1 days in RCP 4.5; whereas it may increase by 0–11 days per season in RCP8.5 by the end of the 21st century.

* The change in maximum temperature is based on MAM, which is observed to be 32.2°C under historical estimates, 33–33.9°C under RCP4.5, and 33.1–35.7°C under RCP8.5

- The HWFI³⁴ is also expected to increase in the range of 16–41 days in RCP4.5, and the intensity is more pronounced in RCP8.5, projected to increase in the range of 18–72 days towards the end of the century (Figure 13).

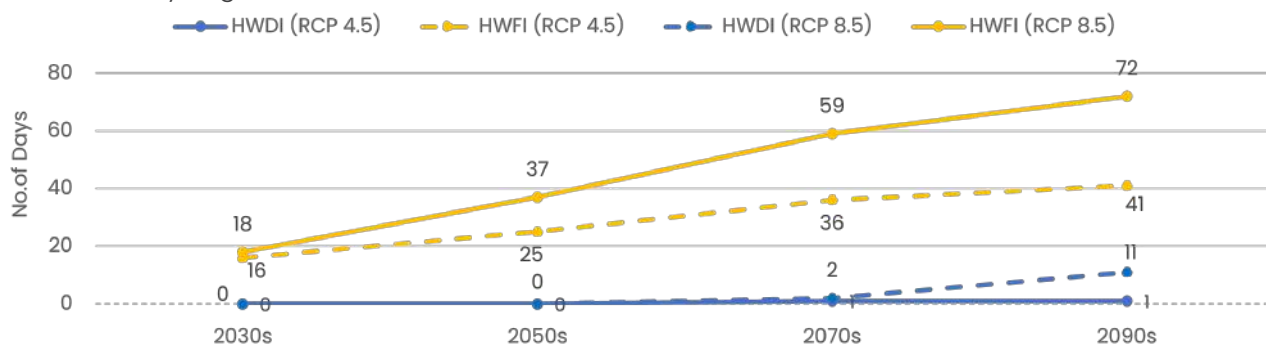


Figure 13: Simulated and projected seasonal temperature extremes, Nilgiris district

Minimum Temperature

- In the winter season (December–January–February), the minimum temperatures also show a projected increase by 0.9°C – 1.9°C under RCP4.5 and 1.0°C – 3.7°C under RCP8.5 (Figure 14)**.

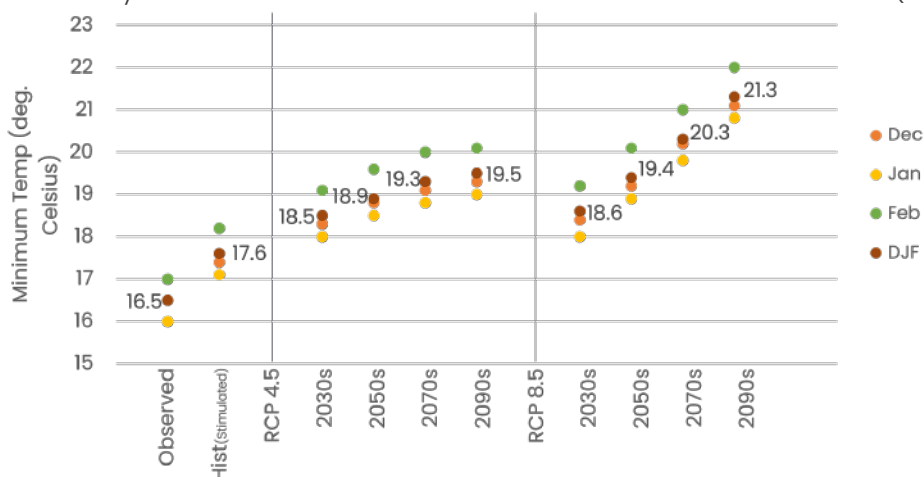


Figure 14: Observed, simulated, and projected monthly and seasonal minimum temperature, Nilgiris district

(The change in minimum temperature is based on DJF, which is observed to be 17.6 °C under historical estimates, 18.5 °C–19.5°C under RCP 4,5 and 18.6°C–21.3°C under RCP 8.5.)

- The percentage of cold days is also projected to decrease in all the epochs under changing climate conditions (Figure 15).



Figure 15: Observed, Simulated, and Projected percentage of cold days, Nilgiris district

** The change in minimum temperature is based on DJF, which is observed to be 17.6 °C under historical estimates, 18.5 °C–19.5°C under RCP 4,5 and 18.6°C–21.3°C under RCP 8.5

3.2 Precipitation



Variability

Southwest Monsoon

- While the rainfall shows no significant trend in June, August, and September, the month of July and the season as a whole show a statistically significant decreasing trend (Figure 16).

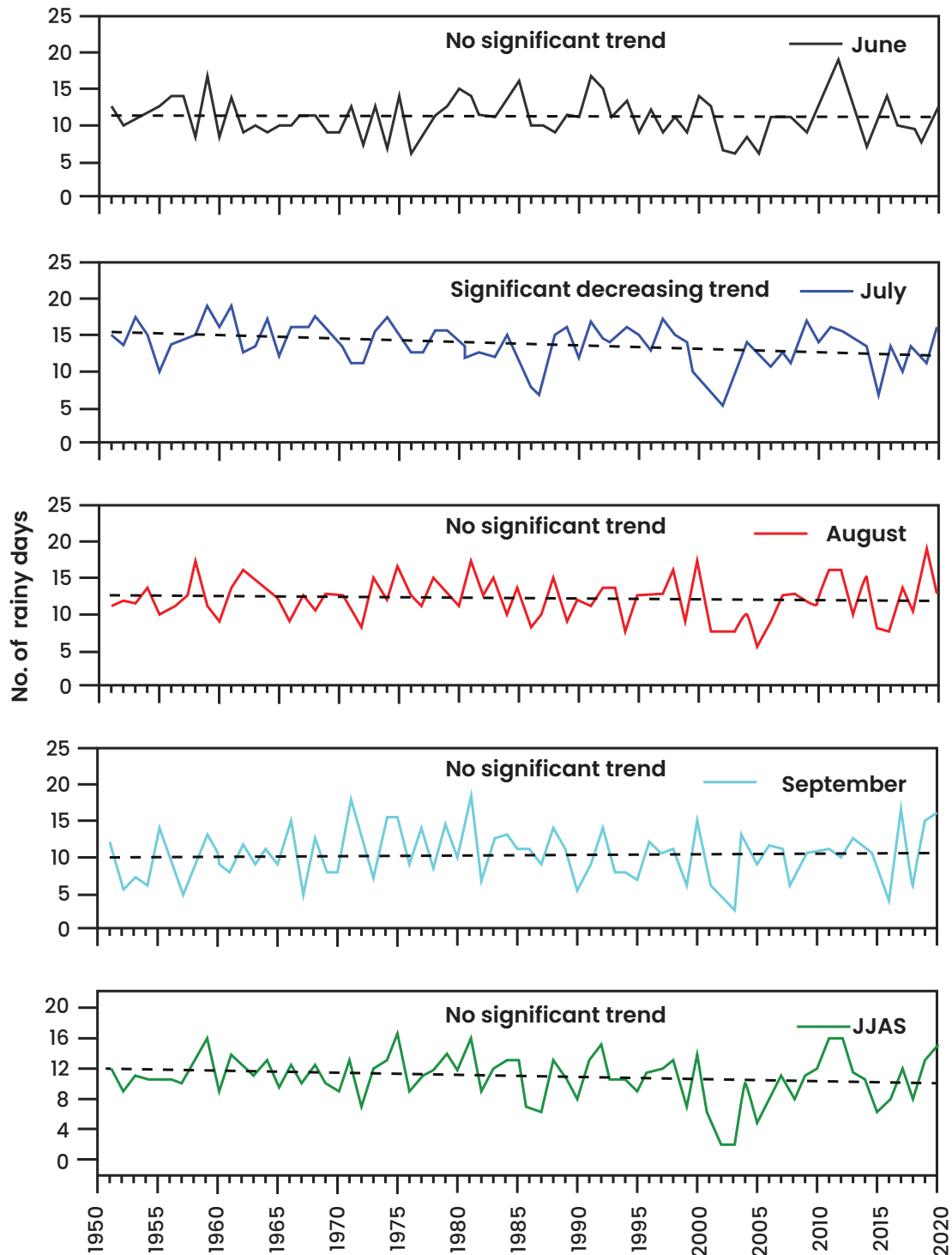


Figure 16: Inter annual variability of southwest monsoon rainy days (days) over Nilgiris for 1951-2020

- Although not statistically significant, the number of rainy days for the southwest monsoon depicts a decreasing tendency in major rainy months (July & August) and the season as a whole (Figure 17).

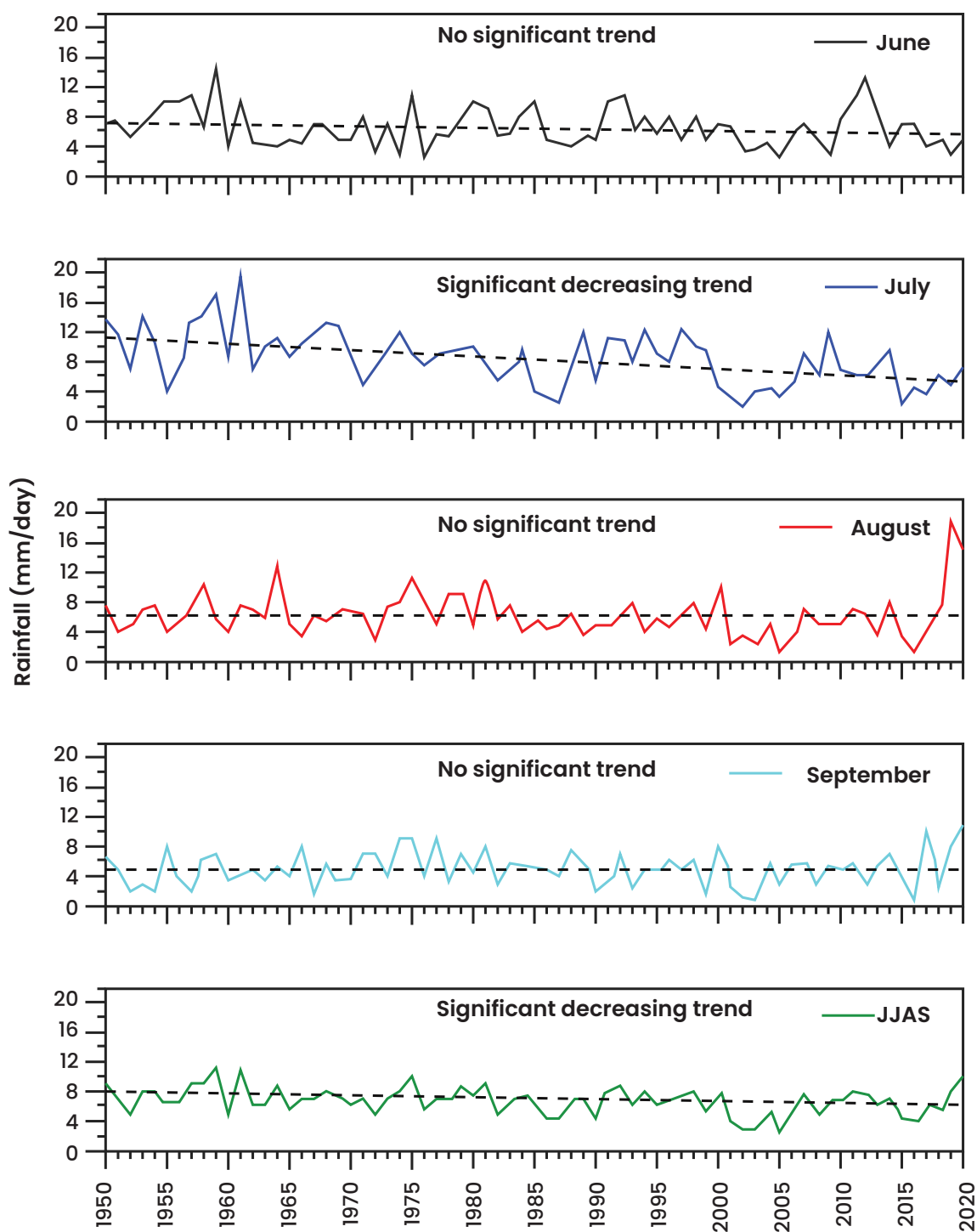


Figure 17: Inter annual variability of southwest monsoon rainfall (mm/day) over Nilgiris for 1951-2020

Northeast Monsoon

- The rainfall and rainy days during the winter monsoon months and the season as a whole do not show any considerable trend (Figure 18).

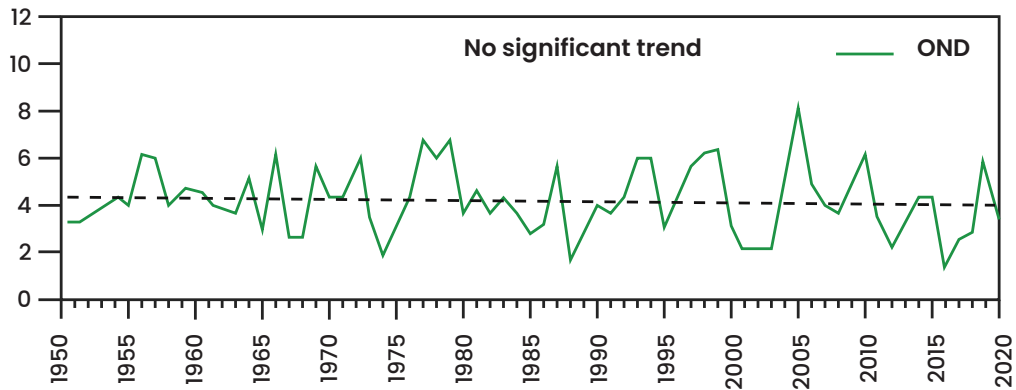


Figure 18: Inter annual variability of northeast monsoon rainfall (mm/day) over Nilgiris for 1951-2020

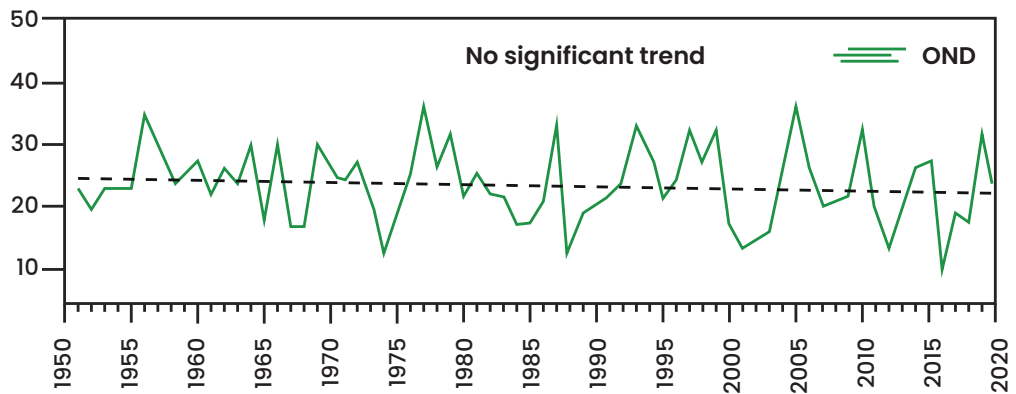


Figure 19: Inter annual variability of northeast monsoon rainy days (mm/day) over Nilgiris for 1951-2020

Projections

Southwest Monsoon

- During the southwest monsoon period, the precipitation may increase between 27% - 36% under RCP 4.5 and 23% - 46% under RCP 8.5 emission scenarios (Figure 20).

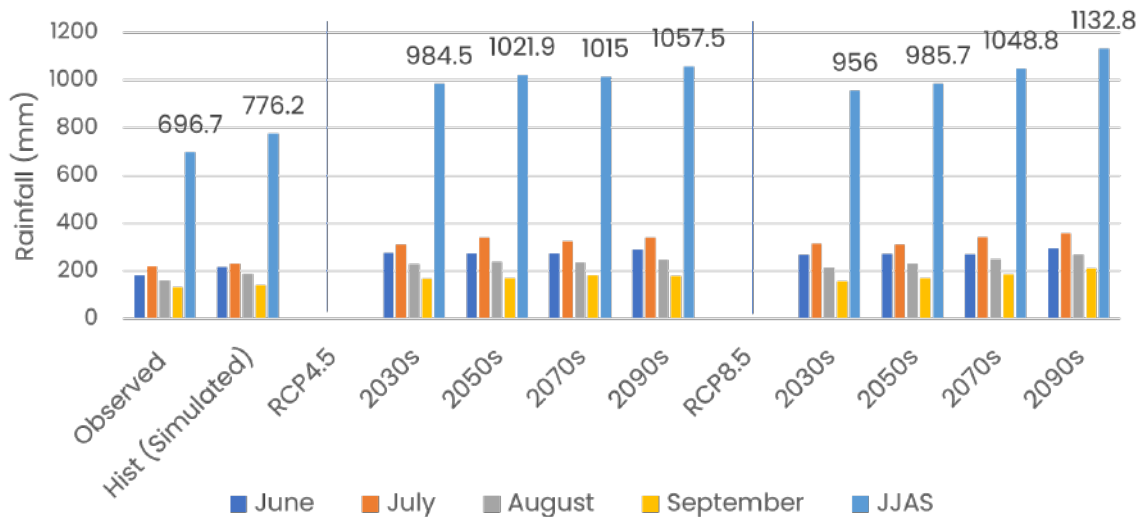


Figure 20: Observed (1986-2005), simulated (1986-2005) and projected mean monthly and southwest monsoon rainfall (mm) for Nilgiris district

- The number of rainy days is projected to increase mainly during July & August in the southwest monsoon season under both RCP4.5 and RCP8.5 emission scenarios (see Table 4).

Table 4: Observed (1986–2005), simulated (1986–2005) and projected southwest rainy days (rainfall >2.5 mm) for Nilgiris district

Obs.	Hist. (Simulated)	RCP 4.5	2030s	2050s	2070s	2090s	RCP 8.5	2030s	2050s	2070s	2090s
43	56		60	59	58	61		57	56	58	60

- There is a slight decrease in the number of consecutive dry days during the southwest monsoon season during the historical period and in the future under RCP 4.5 and RCP 8.5 scenarios (Figure 21).

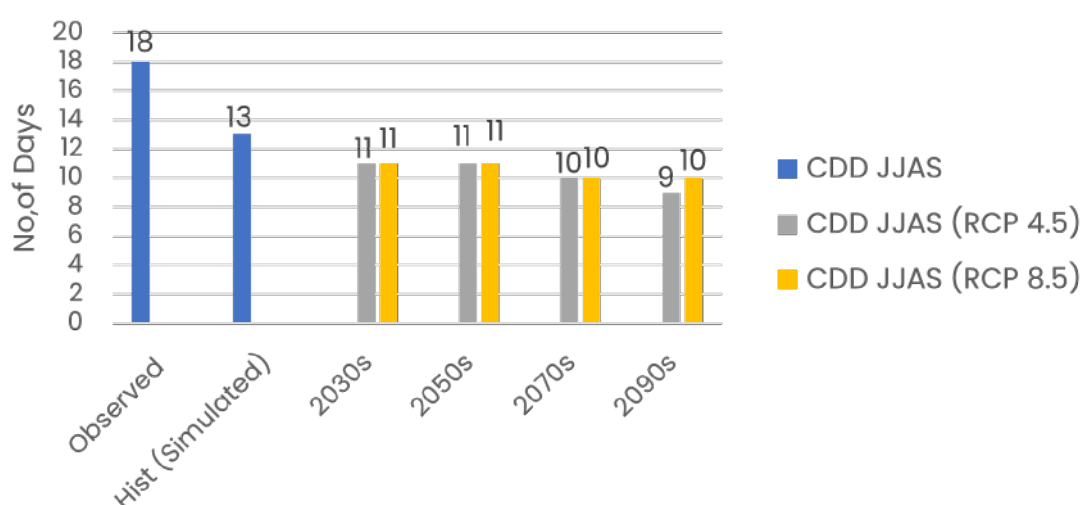


Figure 21: Simulated and projected seasonal (JJAS) precipitation extremes, (CDD), Nilgiris district

- The 1-DAY highest rainfall amount during the southwest monsoon season increases from 88 to 95 mm under the RCP4.5 and from 92 to 111 mm under the RCP8.5 scenarios (Figure 22).
- The 5-DAY cumulative highest precipitation amount during the southwest monsoon is also projected to increase from 188 to 203 mm under the RCP4.5 and from 191 to 229 mm under the RCP8.5 scenarios (Figure 22).

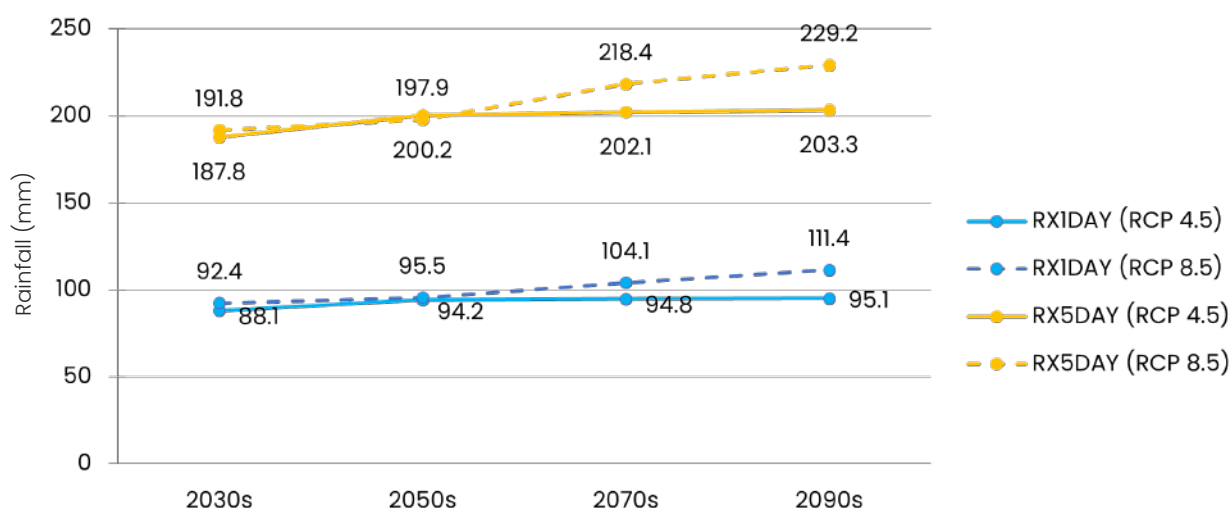


Figure 22: Simulated and projected seasonal (JJAS) precipitation extremes, (RX1 and RX5), Nilgiris district

Northeast Monsoon

- The precipitation during the northeast monsoon is also projected to increase in the range of -3% to 14% under RCP4.5 and 4% to 35 % under RCP 8.5 emission scenarios (Figure 23).

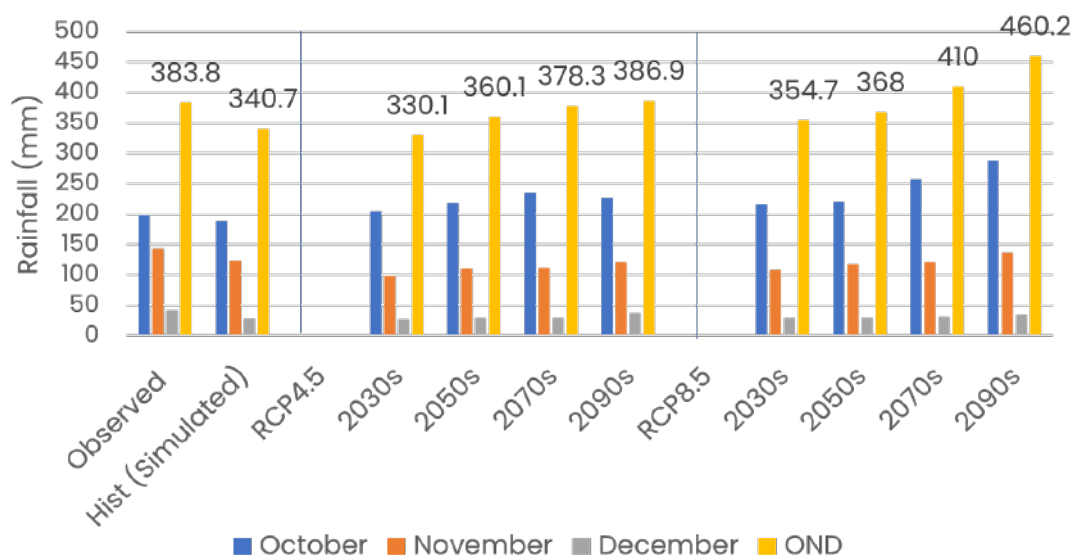


Figure 23: Observed (1986–2005), simulated (1986–2005) and projected mean monthly and northeast monsoon rainfall (mm) for Nilgiris district

- The rainy days for this season are projected to increase by the end of the century under both RCP4.5 and RCP8.5 scenarios (see Table 5).

Table 5: Observed (1986–2005), simulated (1986–2005) and projected northeast rainy days (rainfall >2.5 mm) for Nilgiris district

Obs.	Hist. (Simulated)	RCP 4.5	2030s	2050s	2070s	2090s	RCP 8.5	2030s	2050s	2070s	2090s
24	26		25	28	27	28		26	27	29	30

- There is a slight decrease in the number of consecutive dry days during the northeast monsoon season during the historical period and in the future under RCP 4.5 and RCP 8.5 scenarios (Figure 24).

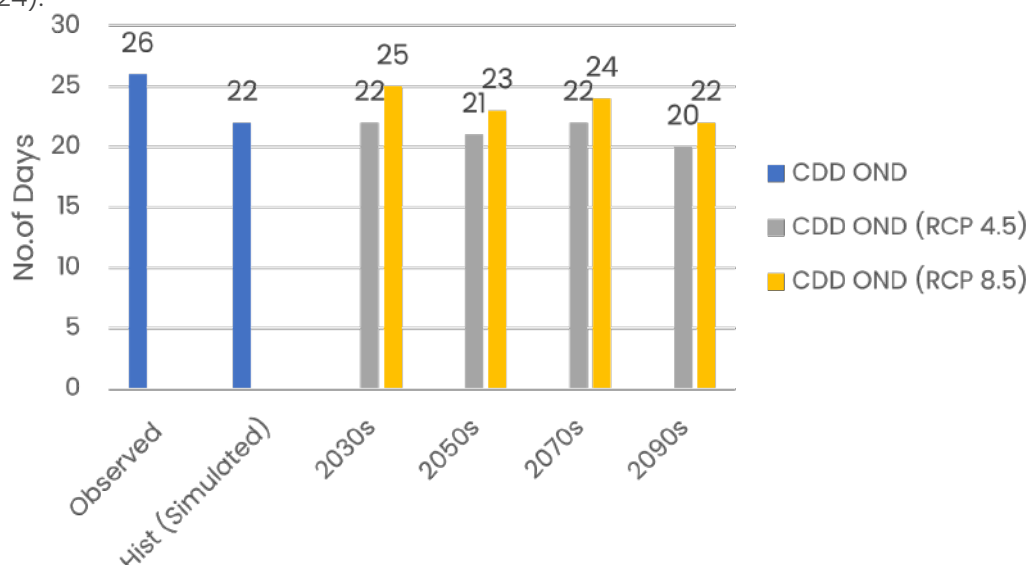


Figure 24: Simulated and projected seasonal (OND) precipitation extremes, (CDD), Nilgiris district

- The 1-DAY highest rainfall amount during the northeast monsoon season shows a moderate increment under the RCP4.5 and RCP8.5 scenarios. Similarly, there is a moderate increment for 5-DAY cumulative highest precipitation amount towards the end of the century (Figure 25).

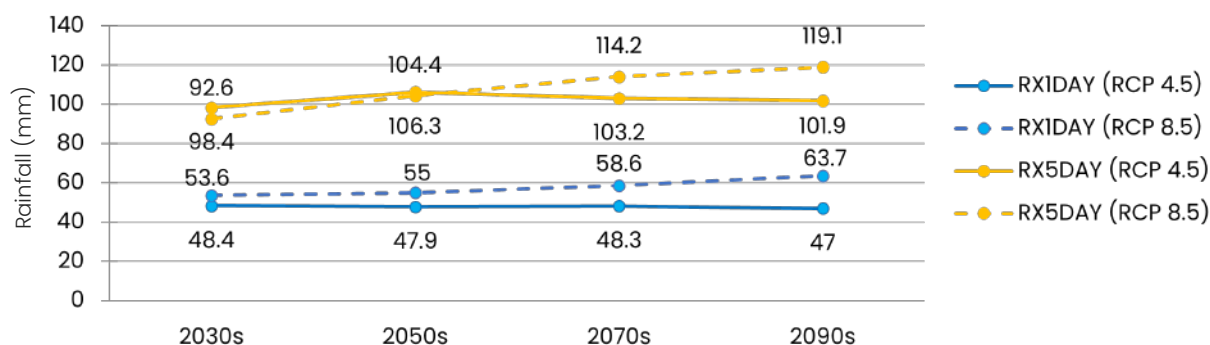


Figure 25: Simulated and projected seasonal (OND) precipitation extremes, (RX1 and RX5), Nilgiris district

3.3 Climate Vulnerabilities

Flash Floods and Landslides

Landslides in the Nilgiris have evolved into an annual occurrence, particularly during the Southwest and Northeast monsoon seasons. These events are often triggered by intense rainfall, which leads to excessive surface runoff and saturation of unstable slopes. Flash floods, resulting from short duration, high intensity rainfall, overwhelm the region's natural drainage systems, causing flooding of adjacent agricultural fields and settlements.

An illustrative example occurred in August 2020, when the district received 487 mm of rainfall, 901% higher than the expected 54 mm. This extreme rainfall event caused extensive damage to infrastructure, houses, roads, and public utilities across the district.

Additionally, high-velocity rainstorms frequently uproot trees, disrupting electricity and communication networks and posing safety risks. Unplanned construction, agricultural expansion on steep slopes, and deforestation further compound the risk, rendering large areas of the district highly vulnerable to landslides.

Water Scarcity

Despite receiving significant annual rainfall, the Nilgiris experiences acute water shortages, especially from January to April. The decline in the number of rainy days, coupled with erratic rainfall patterns, has significantly altered the region's water availability and usage cycles.

Periods of extended dry spells now occur even within monsoon months, leading to irregular replenishment of surface and groundwater resources. The traditional water harvesting capacity of ecosystems such as the Shola grassland ecosystem is under pressure due to land use changes and loss of vegetative cover, resulting in diminished natural sub soil recharge.

Increased demand for water for agriculture, tourism, and domestic use, combined with unreliable supply is intensifying the water crisis. The imbalance between precipitation and groundwater retention poses long term sustainability challenges for both rural and urban communities in the district.

Forest Fires

Forest fires in the Nilgiris are a recurring hazard, particularly during the dry summer months from February to May. These fires are most common in degraded forest areas, monoculture plantations, and human influenced edges of forest zones.

The dry spells, exacerbated by changing rainfall patterns and warming temperatures, create conditions conducive to fire outbreaks. Unregulated human activities such as illegal burning, tourism pressures, and encroachment further increase the frequency and intensity of forest fires.



4. GHG Profile

The greenhouse gas (GHG) emissions estimate for the Nilgiris district has been developed for the period from 2005 to 2022, accounting for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Emissions are reported in terms of CO_2 equivalent (CO_2e) as per the Second Assessment Reports³⁵ (AR2) of the Intergovernmental Panel on Climate Change (IPCC).

The inventory follows the broad guidelines provided by the IPCC, specifically the 2006 and 2019 guidelines, to estimate the GHG emissions. The overall approach and emission factors are sourced from the GHG inventory development methodology followed by the Government of India in its national communication³⁶ and biennial reports.³⁷

The data and information used for the development of the Inventory were sourced solely from official government sources, directly accessed from various relevant departments of the Government of Tamil Nadu and from national organisations such as the Central Electricity Authority and the Petroleum Planning and Analysis Cell, among others.

4.1 Summary of GHG Emission Profile of Nilgiris

The emissions of the greenhouse gasses, namely CO_2 , methane and nitrous oxide, in the Nilgiris district amounted to 11 ktCO_2e in 2022. The energy sector emitted 252 ktCO_2e , while the waste sector contributed 36 ktCO_2e . The Industrial Processes and Product Use (IPPU) sector contributed 0.22 ktCO_2e and the Agriculture, Forestry and Other Land Use (AFOLU) sector was a net sink, removing 278 ktCO_2e . Table 6 below details the category-wise and gas-wise emissions, along with their percentage contributions.

Table 6: Sector-wise and gas-wise GHG emissions (2022)

Sector	GHG Sources and Sink Categories	CO ₂ (kt)	CH ₄ (t)	N ₂ O (t)	CO ₂ eq (kt)
 ENERGY	Road Transport	142	30	7	145
	Residential	69	10	0.6	69
	Commercial	9	0.93	0.04	9
	Agriculture	9	1	0.07	9
	Industries	20	1	0.2	20
	Energy Total	249	42.93	8	252
 AFOLU	Livestock	NA	1171	0.27	25
	Enteric Fermentation	NA	1080	NA	23
	Manure Management	NA	91	0.27	2
	Land	-323	NA	NA	-323
	Forestland	-323	NA	NA	-323
	Cropland	0.004	NA	NA	0.004
	Settlements	-0.005	NA	NA	-0.005
	Other Land	0.001	NA	NA	0.001
	Aggregate Sources	NA	15	68	21
	Biomass Burning in Forestland	NA	5	0.88	0.006
	Biomass Burning in Cropland	NA	0.15	0.004	0.005
	Agriculture Soil	NA	NA	67	21
	Rice Cultivation	NA	10	NA	0.21
	AFOLU Total	-323	1186	68	-278
 IPPU	Non Energy Products from Fuels and Solvent Use (Lubricant Use)	0.22	NA	NA	0.22
 Waste	Solid Waste Disposal	NA	88	NA	2
	Domestic Wastewater Treatment and Discharge	NA	1188	30	34
	Waste Total	NA	1276	30	36
 Net Emissions		-73.78	2504.93	105.91	11

4.2 Economy-wide Emissions

In Nilgiris, net GHG emissions (including Land category of AFOLU sector) decreased from 336 ktCO₂e in 2005 to 11 ktCO₂e in 2022, while gross GHG emissions excluding the land category of the AFOLU sector was 336 ktCO₂e in 2005 and 334 ktCO₂e in 2022. The energy sector was the largest contributor to the district's total economy-wide emissions throughout 2005 to 2022, with emissions increasing from 222 ktCO₂e in 2005 to 252 ktCO₂e in 2022 (Figure 26). The AFOLU sector (including Land category) emitted 80 ktCO₂e in 2005 and became a net sink by 2022, removing 278 ktCO₂e. Emissions from the waste sector remained in the range of 35 ktCO₂e in 2005 to 36 ktCO₂e in 2022. Emissions from the IPPU sector remained negligible, with 0.14 ktCO₂e in 2005 and 0.22 ktCO₂e in 2022.

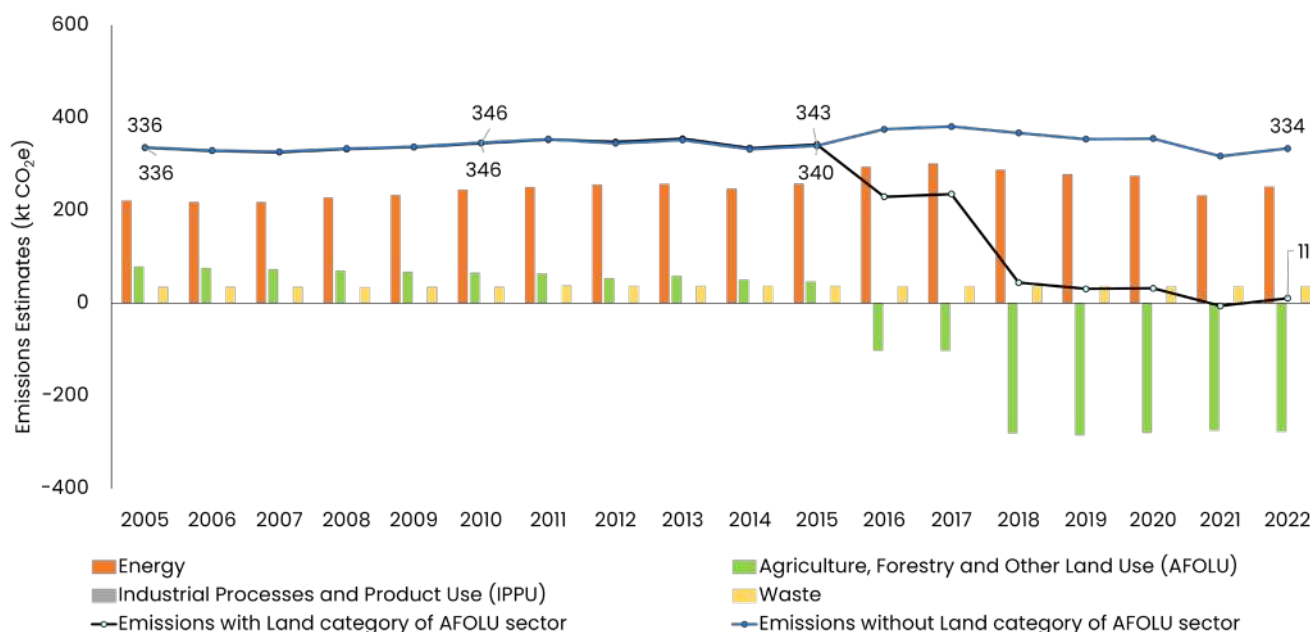


Figure 26: Economy-wide emissions of Nilgiris district (2005-2022)

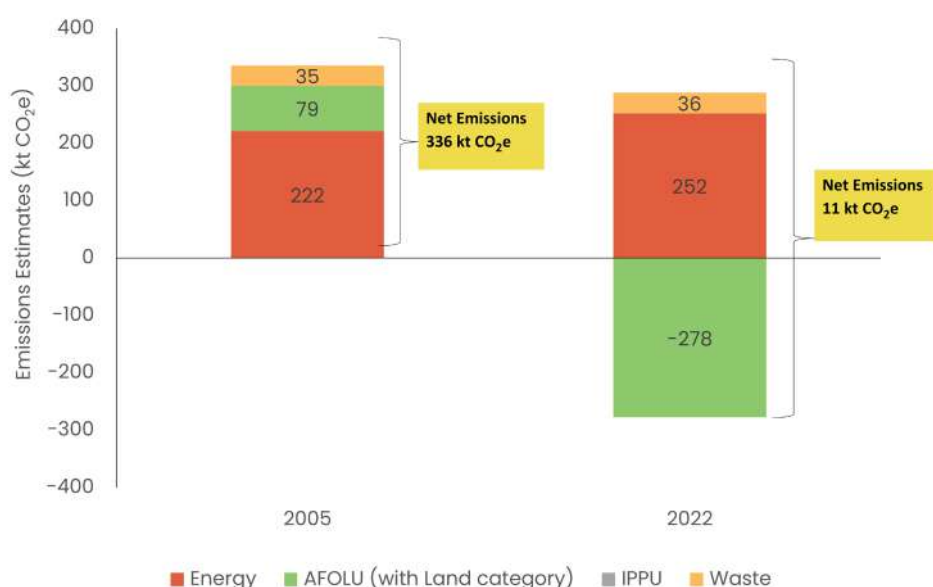


Figure 27: Comparison of sector-wise GHG emissions of 2005 and 2022

Sector-wise comparison and contribution (ktCO₂e) of GHG Emissions in Nilgiris District between 2005 and 2022 is given in Figure 27. The AFOLU sector was a carbon sink, removing 277 ktCO₂e of GHG emissions in 2022.

4.3 Key Category Analysis

Figure 28 shows the key categories that have a major GHG contribution in the Nilgiris District in 2022. Emissions due to road transport was the major GHG contributor (~43%) followed by residential energy (~20%), domestic wastewater (~10%) and livestock (~7%) and agriculture soils and industrial energy (~6%) respectively.

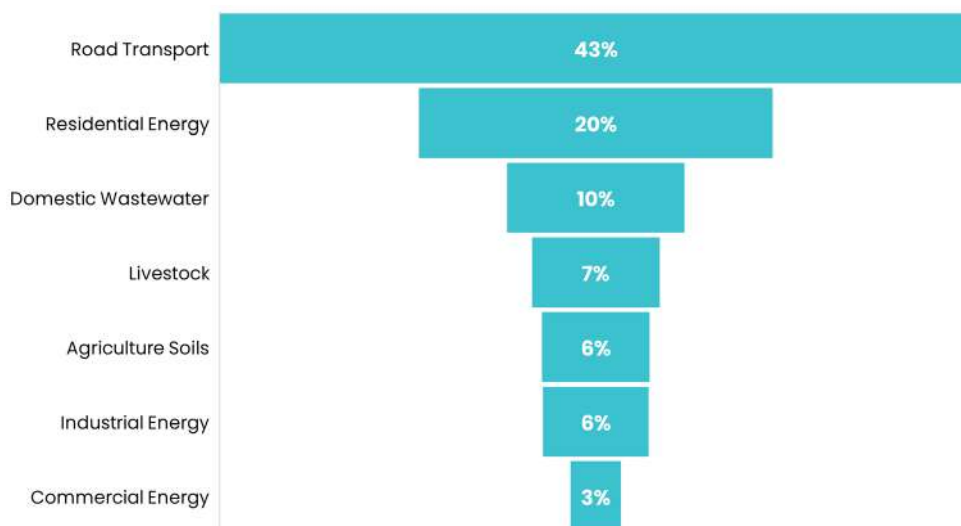


Figure 28: Key category analysis of Nilgiris district (2022)

4.4 Sector-wise Emission Trends

4.4.1 Energy Sector

Energy sector emissions for Nilgiris district include emissions from fuel combustion in road transport, industries, commercial, residential, and agriculture categories. In 2022, the energy sector contributed 249 kt of CO₂, 43 t of CH₄ and of 8 t of N₂O, with total CO₂ equivalents amounting to approximately 252 kilotonnes (see Figure 29) in 2022.

Emissions from road transport increased by 62 percent, from ~90 ktCO₂e in 2005 to ~145 ktCO₂e in 2022. However, emissions from the residential and industrial sub-sectors decreased by 22 percent and 8 percent, respectively.

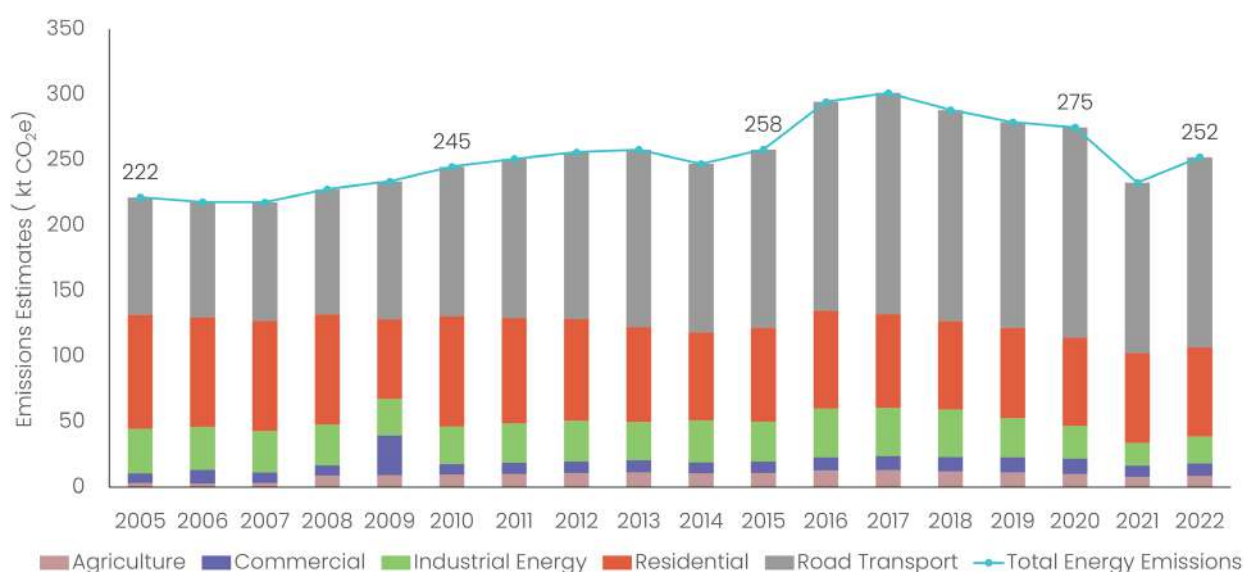


Figure 29: GHG emission estimates of energy sector (2005 to 2022)

4.4.2 Industrial Processes and Product Use Sector

Emissions from the IPPU sector are primarily from the chemical, metal, mineral industries and non-energy products from fuels and solvent use.

The Nilgiris district is mainly a plantation district, with the majority of commercial or industrial scale activities centred on tea processing.

A few of the existing medium and large-scale industries focus on the production of needles, edible mushrooms, tea, and ammunition. Micro and small enterprises are centred around cotton textiles, woollen and other fabric manufacturing, paper and leather based products, and wood furniture. Thus, emissions from the IPPU sector in the district are negligible. with an average of 0.23 ktCO₂e due to lubricant use (see Figure 30).

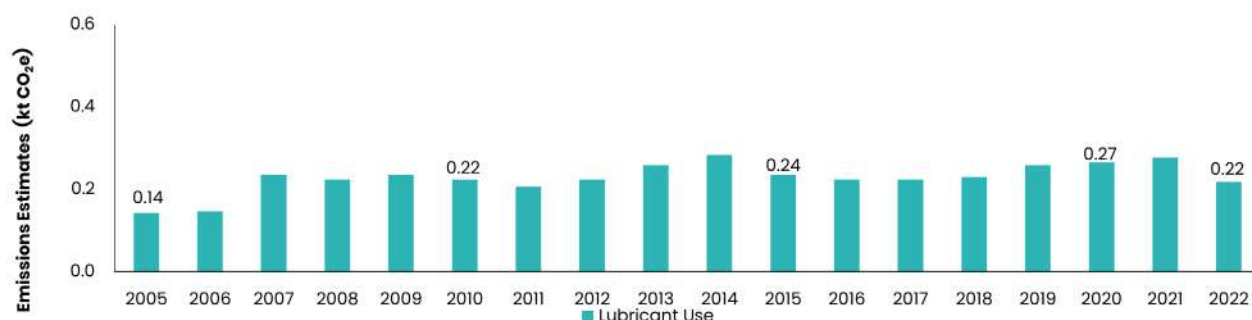


Figure 30: GHG emission estimates of IPPU sector (2005 to 2022)

4.4.3 Agriculture, Forestry and Other Land Use Sector

Emissions from the Agriculture, Forestry and Other Land Use (AFOLU) sector arise from three main sub-sectors, namely Livestock, Land and, Aggregate Sources and Non-CO₂ Emissions Sources on Land. The 'Aggregate Sources and Non-CO₂ Emissions Sources on Land' include emissions from Rice Cultivation, Agriculture Soils, and Biomass Burning in Cropland and Forestland. The Land sub-sector comprises emissions/removals from Forest Land, Agriculture Land, Other Land and Settlements.

The AFOLU sector (with Land category) was a net emitter between 2005 and 2015, with emissions decreasing from 79 ktCO₂e to 47 ktCO₂e. From 2016 onwards, the sector became a net sink, removing an average of 229 ktCO₂e due to the gradual increase in the forest cover (See Figure 31).



Figure 31: GHG emissions estimates of AFOLU sector in Nilgiris (2005 to 2022)

Based on expert inputs, the forest cover (in km²) is calculated as a sum of 'forest area', 'land under miscellaneous tree crops & groves,' and 'permanent pastures and other grazing lands' (Source: Nilgiris District Statistical Hand Books), since the forest cover, as per FSI 'India State of Forest' report, shows a steep decline during the study period. Removal of invasive tree species such as Lantana, Black wattle, Scotch broom, and Gorse could contribute to this steep decline in forest cover.

The carbon stock density is available only at state level in the FSI report. Since the overall geography of Tamil Nadu state is dry and arid, it does not reflect the geography of the Nilgiris District, which features tropical evergreen forest, sholas, grasslands, and savannah woodlands etc., that have a higher tree density. Therefore, a carbon stock of 15 tonnes/hectare was added to the Carbon Stock Density of Tamil Nadu to deduce the Carbon Stock Density of Nilgiris district, based on inputs from forest department (further detailed in Annexure 5).

The gross emission of the AFOLU sector (without the land category) was 45.70 ktCO₂e in 2022, with enteric fermentation accounting to ~50 percent and agricultural soils ~46% (see Figure 32). The emission from livestock management (enteric fermentation and manure management) has seen a gradual decrease due to dwindling cattle population.

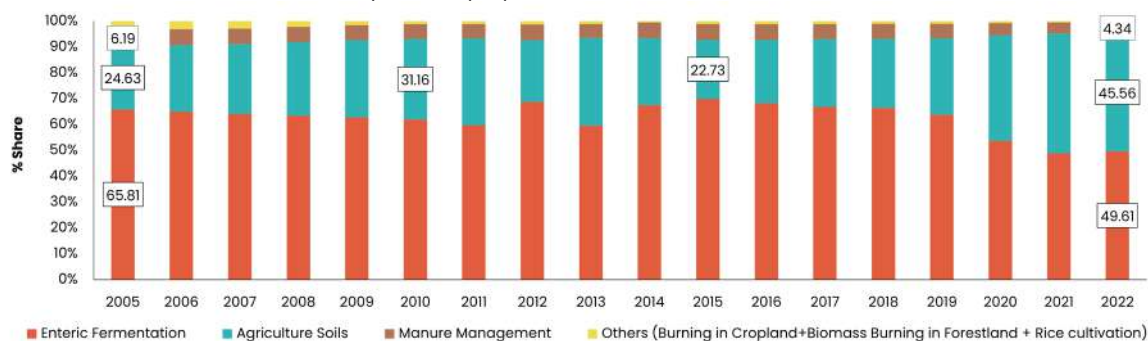


Figure 32: Category-wise share of positive AFOLU emissions (excluding land sub-sector) (2005 to 2022)

4.4.4 Waste Sector

GHG emissions in the waste sector primarily arise from solid waste disposal and domestic wastewater treatment, as there are no prominent wastewater generating industries in the Nilgiris. The waste sector contributed ~1,276 tonnes of CH₄ and 30 tonnes of N₂O accounting to ~36 ktCO₂e in 2022. The Waste sector emission has increased by 2 percent with 35 ktCO₂e emission in 2005 and 36 ktCO₂e in 2022. The annual emissions from the waste sector is as represented in Figure 33.

In 2022, solid waste disposal accounted for 5 percent of the emissions from the waste sector, while domestic wastewater treatment and discharge accounted for 95 percent. Of this, ~24 ktCO₂e was emitted from urban domestic wastewater (69%) and ~10 ktCO₂e from rural domestic wastewater (31%), as represented in Figure 34.



Figure 33: GHG emissions estimates of waste sector for Nilgiris (2005 to 2022)

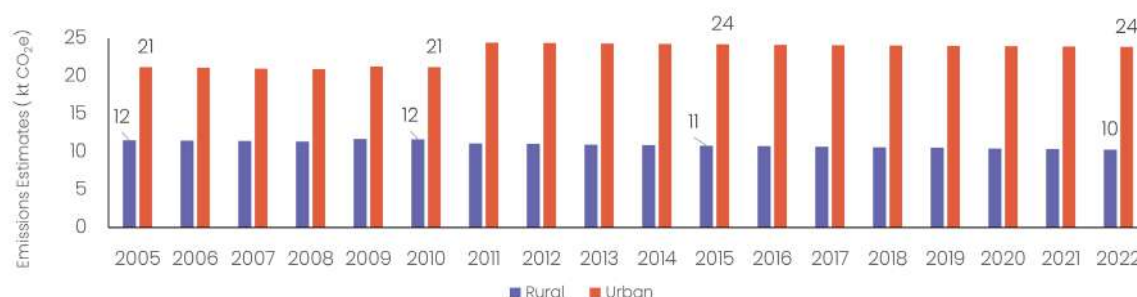


Figure 34: Area-wise GHG emissions estimates of domestic wastewater (2005 to 2022)

5.

Deep Dive into District's Energy and Other Sectors (AFOLU & Waste) and Projections to 2050

Key Highlights of the Demand Outlook in 2050

- With the current growth rate of economy together with national and state policies in place, the total energy supply is projected to reach 6.3 PJ by 2050. The Gross GHG emissions in the BCS are, thus, expected to increase from 334 ktCO₂e in 2022 to 448 ktCO₂e by 2050.
- With full implementation of decarbonisation measures, the GHG emissions could show a reduction of 62 percent to 172 ktCO₂e, compared to BCS 2050.
- The district has existing carbon sink of 323 ktCO₂e, due to vast presence of forests, shola grassland. Enhancing the carbon stock density & agro forestry can thus help achieve an additional land-based sequestration of 174 ktCO₂e over and above BCS by 2050.
- The district can achieve carbon neutrality status well before 2030 through energy sector decarbonisation measures and land-based sequestration.
- From electricity standpoint, district is already carbon neutral, even as the electricity demand is expected to double by 2050. Electricity consumption is expected to rise from 424 GWh to 711 GWh in MES and 865 GWh in AES by 2050. Clean generation from hydro plants in the region is anticipated to be ~2100 GWh.
- Electrification of road transport, measures to enhance use of public transport and non-motorised transport are expected to contribute the most to reduction of GHG emissions, with an abatement potential of 86 ktCO₂e by 2050.
- Fuel switching measures for cooking such as the use of electric cookstoves, are expected to abate almost 55 ktCO₂e of GHG emissions by 2050. Similarly, switching from wood-based heaters to electric heat pumps in tea Industry is expected to abate ~38 ktCO₂e by 2050 as compared to BCS 2050.
- Energy efficiency improvements in residential appliances (water heaters, space heaters, refrigerators, lighting etc) and commercial buildings (hotels, institutions etc.) are expected to avoid ~49 GWh of the electricity consumption in 2050 compared to BCS.
- Efficient use of wastewater could drop waste sector emissions to near zero from current level of 36 ktCO₂e.

5.1 District Energy Use and Demand Projections to 2050

In this chapter, we delve into the energy dynamics, to build a sectoral understanding of both the primary and final energy mixes in Nigiris. The primary objective of this chapter is to project the trajectory of energy consumption, production and energy trade in the Nilgiris district, up to 2050. This will help decipher the interplay of various energy sources and policies that will shape the future of the district, aligning with the national target of achieving net zero by 2050. For example, the 2023 EV policy of the state is expected to transform the transport sector; similarly, the PM KUSUM scheme supports solar energy-based irrigation, thus reducing reliance on diesel.

Within this chapter, our focus spans across five main sectors: electricity use, road transport, heavy and small industries, buildings, and cooking (both residential and commercial). Additionally, this chapter discusses the methodology and approach followed for projecting the energy requirements for future years. Finally, it presents the aggregate results on energy requirements and corresponding greenhouse gas (GHG) emissions from the energy sector.

Limitations to the Study	While the demand projections are based on robust, sector-specific methodologies, there are certain sectors where data were unavailable. In such cases, projections were made using available growth rates.
	In addition to data from primary sources, such as Nilgiris district offices, secondary data sources at both national and international levels were relied upon whenever data were missing or not maintained in the required format.
	The availability of commodity wise data was limited to this study. For example, non availability of lighting stock, industrial production, agro machineries as per primary surveys were partially available and thus required the use of secondary sources.

5.1.1 Transport Sector

The hilly terrain of the Nilgiris is navigated through a network of roads, making road a dominant mode of transport for the district. As in February 2024, the total number of vehicles registered in the district was 1,05,375, of which 89 percent of the vehicles are in the non-transport category (vehicles that are not primarily used for transporting goods or passengers for hire or reward). The majority of the registered vehicles were two-wheelers, followed by four-wheelers. Refer to Table 7 for the type of vehicles registered in the district. In terms of fuel type, 75 percent of vehicles were registered as petrol vehicles, followed by ~25 percent registered as diesel vehicles and a modest 180-200 number of registered as electric vehicles.

Table 7: Registered vehicles as on 1.02.2024 in the district (Source: District RTO)

Vehicle Category	Registered Vehicles (in Numbers)
2-wheelers	64,271
3-wheelers	2,292
4-wheelers	26,817
Buses	524
Goods Vehicle	2,748
LMV Passenger	1,112
Others	7,611
Total Vehicles	1,05,375

In addition to privately and publicly owned vehicles, many tourist buses operate shuttle services up and down the hills, as well as commercial tourist services. Since the district is dotted with many tourist attractions and destinations, these areas see significant tourist footfall and, therefore, a high volume of vehicles.



Methodology for Vehicle Stock and Energy Demand Projection till 2050

To project the road transport demand in the district, a vehicle stock model was used, which projects the total vehicle ownership per capita across the light and heavy-duty vehicle segments. Logistic regression was used to derive relationships with future demographic variables (population) and vehicle ownership. To assess the growth over past years, the historical ownership patterns across vehicle categories was studied using the data from District RTO, District Statistical Handbook³⁸ and census^{39,40}, thus giving a two decadal growth estimate between 2001 to 2024.

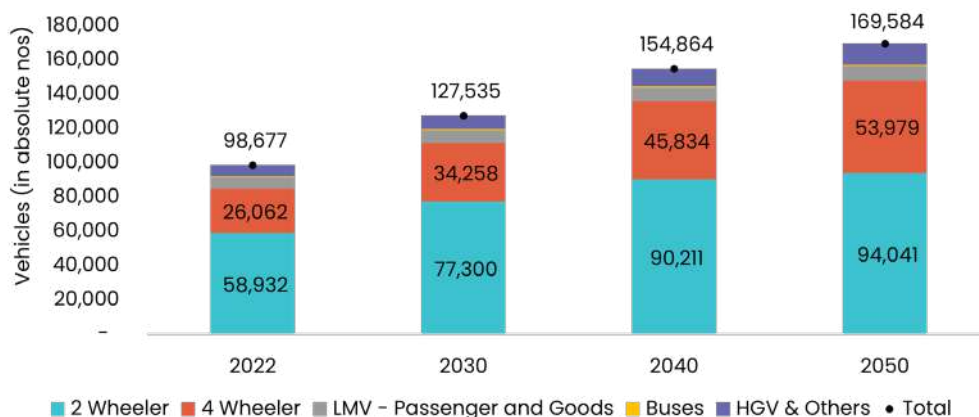


Figure 35: Stock of vehicles by category from 2024 to 2050

(Note that 'Others' not shown in the figure due to its vehicle registration outside the district RTO boundary)



Demand Projection for Transport

It is estimated that the stock of vehicles in the district is expected to grow to 1.66 lakh from the current level of 0.98 lakh between 2024 and 2050. Approximately 72 percent of the new growth in vehicles is estimated to be from two wheelers and four wheelers. Thus, it is a priority segment within road transport to electrify the two and four wheelers. Subsequently, total fuel demand is estimated to grow to 74 Million Litres in 2050 from 56 Million Litres in 2022. Further, ~20 percent of the fuel demand rises from the 'others' category, of which 68 percent caters to the residual demand i.e. tourist commercial vehicles inflow in the Nilgiris. The share of commercial vehicles fuel demand is assumed to increase in the coming years following the rate of tourist arrivals in the past few years. Figure 35 shows the share of growth of vehicles in the district. An interesting aspect which can be observed is the declining growth of overall private vehicle categories. Even in the two wheeler and four wheeler segment, the annual growth of vehicle registrations slows down to 0.81 percent between now and 2050 as compared to the pre-covid decadal growth rate of 8.2 percent in the district.

To evaluate the role of electrification of the road transport fleet, we assess the quantum of electrification needed through the scenarios developed within this study. Table 8 shows the scenario wise percentage of new sales of various Electric vehicles.

Table 8: New EV sales target as a percentage of new vehicle sales in the district

Vehicle Category	BCS		MES		AES	
	2030	2050	2030	2050	2030	2050
2 Wheeler	15%	35%	45%	80%	70%	100%
4 Wheeler	7%	20%	15%	45%	30%	70%
Buses	5%	8%	10%	35%	20%	50%
Trucks	0%	2%	5%	10%	10%	20%
3 Wheeler	12%	30%	60%	75%	70%	100%



Electricity Demand from the Transport Sector till 2050

With only a modest number of electric two-wheelers in the district, the share of electricity consumption in road transport is limited currently. The new demand for electricity in road transport is estimated to be supported from the current policies in place which supports subsidies on upfront purchase of vehicle in light to medium duty vehicle categories. It is thus expected that there could be an increase of EV Stock to ~1.4 lakh by 2050. Subsequently, the demand for electricity from the road transport could rise to ~73–123 GWh by 2050. Figure 36(a) below shows the electricity consumption across the vehicle categories. The electricity consumption in the coming years is predominantly expected to be shared by Cars, HGV and Buses.

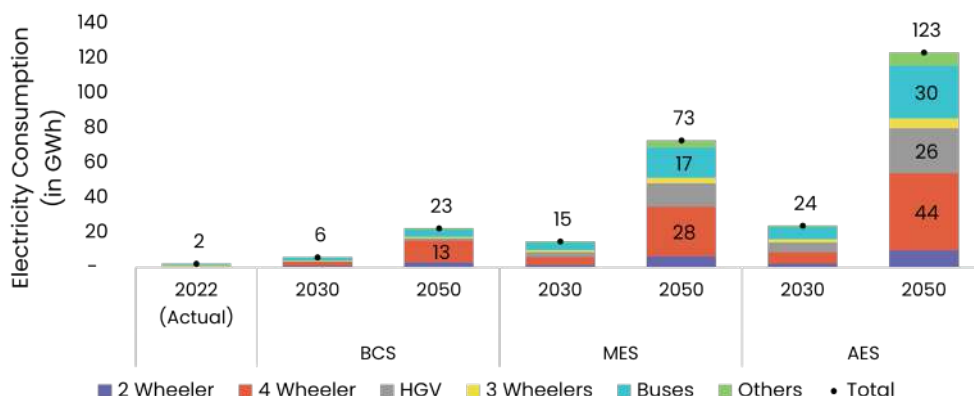


Figure 36(a): Road transport electricity consumption across the scenarios

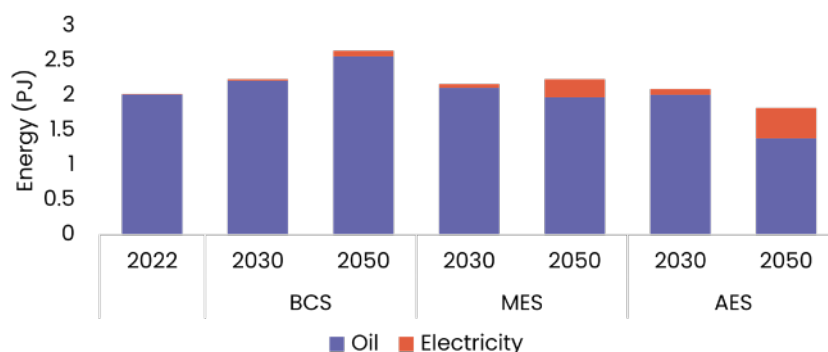


Figure 36(b): Energy supply in the transport sector

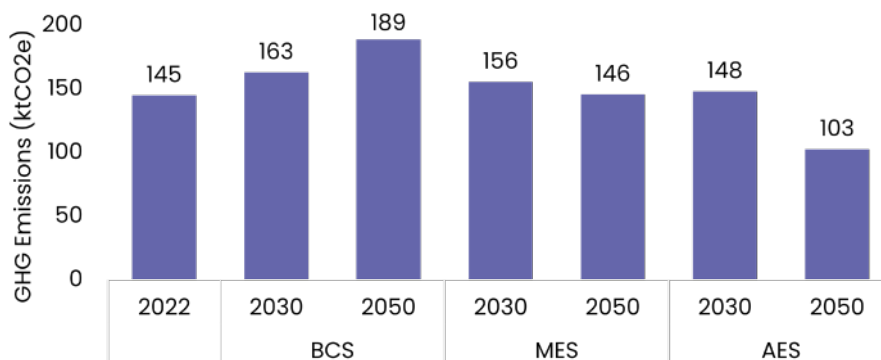


Figure 36(c): Road transport GHG emissions in the BCS, MES, AES scenario

Figures 36(b) and 36(c) show energy consumption from the road transport sector. In the BCS, oil demand increases by almost half to 2.6 PJ as compared to the baseline year. Oil demand reduces significantly from 2 PJ in 2030 to 1.25 PJ by 2050, with a sharp increase in electricity use from 0.09 PJ to 0.49 PJ during the same period. Between 2022 and 2050, emissions increase by 30% from 145 ktCO₂e to 189 ktCO₂e, dropping significantly to 103 ktCO₂e in the AES due to electrification of 2W, 3W, 4W, buses and HGVs.

Policy and structural shifts can give Nilgiris a head start in sustainable tourism and transport



The Nilgiris – a tourist destination with significant vehicular traffic, can harness Tamil Nadu's initiatives to push electricity mobility of its own accord. Under the TN Electric Vehicle Policy 2023,

- The State Government has announced incentives up to Rs. 5000 for procurement of e-cycles, Rs.30,000 for e-2W, Rs. 40,000 for e-3W, Rs. 1,50,000 for e-4W and Rs. 10,00,000 for e-buses. In addition, a 100% road tax has been exempted, and registration charges and permit fees waived for electric vehicles in the State till 31.12.2025.
- Furthermore, to promote EV supply, electricity tax on EV manufacturing has been exempted for the period of five years and a 100% reimbursement of SGST is being offered on a minimum investment of Rs. 50 crores and generation of at least 50 jobs.
- A total investment of Rs. 50,000 crore in EV manufacturing and generation of 1.5 lakh new jobs is targeted under the policy. It also targets increasing the share of electric buses to 30% of the fleet by 2030.

Further extension of the timeline under EV policy, and its impact on the transport sector, could be explored. In Ooty particularly, a hill station characterised by its longer tourist and hill routes, e-buses can yield reduced operational costs owing to efficiency gains from regenerative braking and consistent speed profiles. By accounting for such elevation gains and braking patterns, co-locating charger locations with rest stops or depots, and other strategic elements, Nilgiris can optimise its plan for developing the district into a sustainable transport hub.

A Business Case for Electric Buses in the Nilgiris



The adoption of electric buses in Nilgiri offers a viable and economically sound solution for public transit. The technology is particularly well-suited to the region's hilly terrain and ecological sensitivity. A comprehensive Total Cost of Ownership (TCO) analysis, assuming a 10-year vehicle life, confirms that e-buses have achieved TCO parity and offer a distinct financial advantage over conventional diesel (ICE) buses. Specifically, for the 9-meter bus segment, the TCO per kilometer for an e-bus is between ₹50.50 and ₹62.25, markedly lower than the ₹64.94 to ₹76.69 for its ICE counterpart. A similar advantage is seen in the 12-meter category, where the e-bus TCO ranges from ₹55.96 to ₹63.29 per kilometer compared to ₹71.99 to ₹84.79 for diesel buses. While various models and battery technologies are readily available, the successful implementation of an e-bus fleet in the Nilgiris is contingent upon a detailed route terrain analysis. This analysis is essential to accurately determine the final specifications for battery capacity and motor sizing needed to navigate the unique gradients and elevations of the local ghat roads effectively.

Manufac-tures	Vehicle Model	Seating	Length(m)	Maximum Power(kW)	Range(kms)	Charging time
TATA	Starbus	31+D	9	245	150	2 to 2.5 hrs
TATA	Starbus	35+D+WC	12	245	200	2 to 2.5 hrs
Switch Mo-bility	EiV12	39+D+WC	12	235	300	<2 hrs
Eka Mobility	Eka 9	31+D+WC	9	213	200	2.5hrs/1.5 hrs
Eka Mobility	Eka 12	54+D	12	NA	250	3.5hrs/2.5hrs

Furthermore, in Ooty particularly, a hill station characterised by its longer tourist and hill routes, e-buses can yield reduced operational costs owing to efficiency gains from regenerative braking and consistent speed profiles. By accounting for such elevation gains and braking patterns, co-locating charger locations with rest stops or depots, and other strategic elements, Nilgiris can optimise its plan for developing the district into a sustainable transport hub.

Regulatory Measures towards Sustainable Tourism in the Nilgiris

In response to the severe environmental and social strain caused by excessive traffic, as identified in the Madras High Court case (W.P.No. 15120 of 2019), measures have been taken to manage the vehicle influx into the ecologically sensitive Nilgiri hills. A whopping 20,011 vehicles are entering the Nilgiris every day, which includes 11509 cars, 1341 vans, 637 buses, 6524 two-wheelers on an average during the peak season. The roads are carrying beyond their capacity. The court noted that the alarming number of vehicles was causing irreparable damage to the biosphere, disrupting the lives of residents and harming wildlife.

To address this, a cap on the carrying capacity of vehicles was implemented. The results from the initial phase have been positive. For instance, due to the implementation cap on vehicles at 6,000 on weekdays and 8,000 on weekends, there has approximately been a 25 ktCO₂e GHG emissions reduction in the period from April to June 2025. This demonstrates a direct positive environmental outcome from regulating vehicle access to protect the region's fragile ecosystem.

Policy Recommendations

01.

Electrification of Two- and Four- Wheelers

By 2030, ensure at least 70 percent of new two-wheeler and 30 percent of the four-wheeler sales are electric, supported by existing policies in place. By 2050, this segment should reach 90 percent electrification, with additional support from the Government of Tamil Nadu (GoTN) subsidy scheme.

02.

Decarbonise the Tourism Fleet

By 2030, target 30 percent electrification of tourist buses and commercial fleets operating within the district. By 2040, mandate full electrification of all tourist services to manage the growing fuel demand and emissions from this sector. Dedicated parking space in tourist areas with charging stations needs to be prioritised.

03.

Expand EV Charging and Renewable Energy Supply

By 2030, establish a comprehensive network of EV charging stations in tourist and residential areas, integrated with solar energy where feasible. By 2050, ensure 100 percent of the transport sector's electricity demand (123 GWh) is met by renewable energy sources.

04.

Non-motorised Transport

Develop dedicated cycle lanes in the town and develop infrastructure for public bike-sharing systems. Walking lanes for pedestrians should be prioritised.

5.1.2 Agriculture Sector

The Nilgiris district, which falls under a hill and high altitude agro-ecological zone, is a horticulture rich district. Terrace farming and cultivation on narrow slopes are practiced in the district, with 60 percent of the cultivable land falling on slopes. Given the terrain, paddy is cultivated relatively less in the district. Rice production in the district has seen a sharp decline of about 84 percent, dropping from 4727.8 tonnes in 2005 to 782 tonnes in 2021.

The district is known for its rich production of fruits and vegetables, with temperate crops such as tea, potato, cabbage, carrot, beans, plum, peach, pear etc., grown at higher elevations. Mandarin orange, coffee are cultivated at mid-elevation, while tropical crops like clove, nutmeg, pepper, ginger and fruits like durian, litchi, rambutan and mangosteen are grown at lower elevations. Ragi, samai (millet), and wheat are also grown in the district. As of the 2021-22, the cultivated crop area stood at 76,477 ha. However, the annual agriculture production of the district has been declining over the years. Plantation farming is also a significant part of the economy for the Nilgiris. Given the suitable soil and climate for tea cultivation, around 52,000 ha. are under tea cultivation. Coffee plantations are also significant, with 8,016 ha under cultivation as per 2016-17 figures.



Electricity Demand for Irrigation

Of the total net sown area in the district, only 8590 Ha, i.e. 11 percent of the total land, is under groundwater irrigation. Further, it is important to note that the majority area under irrigation comprises horticultural crops, including carrot, beetroot and other cruciferous vegetables. Other agricultural output under irrigation include ginger, potato and vegetables.

From 2000 to 2022, the number of electrified groundwater pump sets rose from 1,009 to 1,896. It has been observed that electricity demand for irrigation pumping has grown only recently, doubling in the past few years to 2.2 GWh in 2022, which accounts for 1 percent of the district's total electricity demand. A stock-based data assessment of electric pumps was conducted and projected to 2050. It is estimated that in the coming 25 years, the number of electric pumps could increase to 3,044, thus consuming 4.5 GWh of electricity.

Furthermore, it is assumed that existing diesel pump sets will be replaced with decentralised solar pumps as part of the PM KUSUM scheme component B. Consequently, these pumps will adopt a more decentralised and captive nature. This shift aligns with broader initiatives to transition towards sustainable and renewable energy sources, contributing to both energy efficiency and reduced environmental impact. Its mitigation impact is discussed in chapter 7.

In addition to agricultural pumps, there are 358 diesel tractors operational in the district⁴¹. Based on the previous growth in stock of tractors, 630-650 additional tractors are expected to become operational by 2050.⁴² Thus, the diesel consumption is expected to rise, resulting in increase in GHG emissions from 9 ktCO₂e in 2022 to 12 ktCO₂e by 2050 in the BCS.

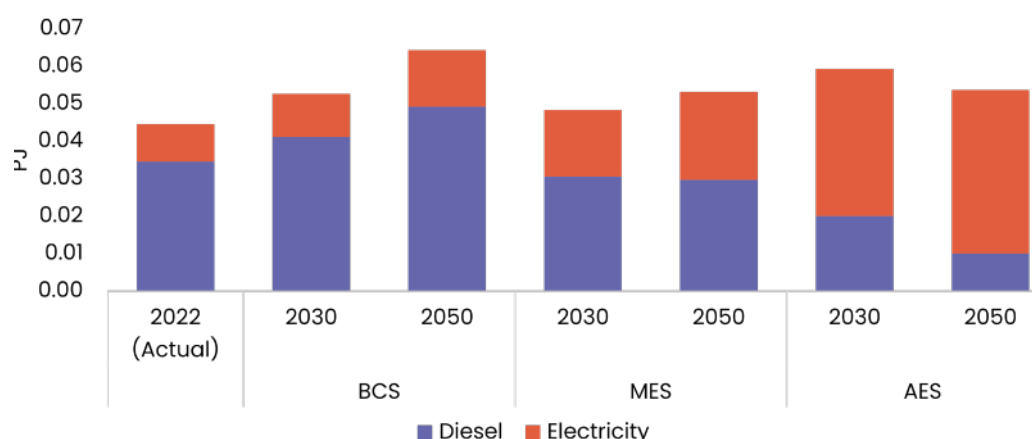


Figure 37(a): Aggregate energy requirement in agriculture sector

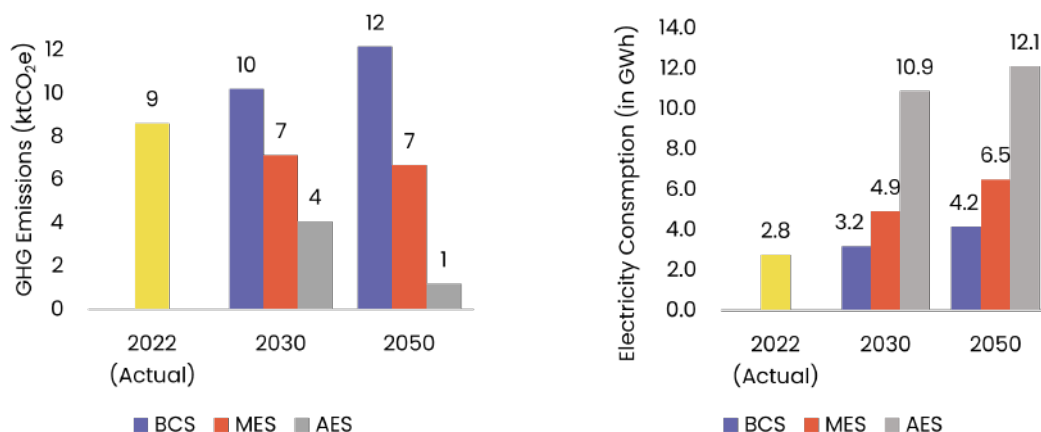
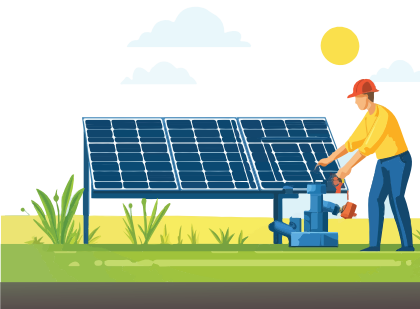


Figure 37(b), (c): GHG emissions in the agriculture sector, aggregate electricity requirement in agriculture sector

Figure 37(a), (b), (c) shows projected energy, electricity consumption and GHG emissions across the scenarios in the district until 2050. Electricity demand increases across all scenarios from 2 GWh in 2022 to 10-12 GWh in 2050, reflecting ambitious electrification efforts in the agricultural machineries and pumping. GHG emissions rise moderately in BCS and MES, while AES shows a sharp decline, reaching 1.2 ktCO₂e because of electrification of agromachinery by 2050, indicating a strong focus on decarbonisation and clean energy uptake.

Policy Recommendations



01. Electrification of Irrigation Pumps

By 2030: Replace 100 percent of diesel pumps with decentralised solar pumps under PM KUSUM. By 2050, fully electrify and solarise all irrigation pumps, reducing electricity demand to 4.5 GWh while cutting GHG emissions.



02. Transition from Diesel Tractors and Agro Machineries to Electric-based Machineries

Explore the possibility of replacing diesel tractors and tillers with EVs in a long term.

5.1.3 Industries Sector

The Nilgiris district is mostly renowned for its tourism and hospitality industry, as well as potential in a blossoming floriculture industry. A major component that fuels the travel and tourism industry are the tea plantations in the district. The presence of these tea plantations contributes to an active tea manufacturing industry in Nilgiris, with more than 200 tea manufacturing units. In terms of medium to large industries there are multiple units for needles, photo films, and cordite manufacturing. Other than these industries, the district is mostly characterised by many small-scale and cottage level industries. There are many micro and small enterprises that include manufacturing of agro-based products, textile & garments, paper based products, rubber, etc. The khadi and village industries include paper bag manufacturing and Eucalyptus oil extraction units and other cottage based industries include chocolate making units.



Methodology for Projection of Electricity Demand from Industrial Sector till 2050

The predominant presence of tea processing industries uses thermal as well as electrical energy for processing tea leaves to produce refined tea as a final commodity. In the district, tea processing industries are placed both in large, as well as medium sized output. In FY 2022, the total tea production

from the district was 1436 tonnes⁴³. As of 2021-22, out of the total 254 large industries, 176 were registered as tea processing units. Further, there were 3176 micro, small and medium enterprises, as well as 284 cottage industries producing various industrial output and services. (Source: District Statistical Handbook -2021-22).

To estimate the electricity demand in industries, data from TNEB as per the consumer category (HT, LT, Cottage industries) was sourced from 2016 to 2022. The electricity consumption across various consumer categories were projected to 2050 assuming past growth and similar energy efficiency level improvements.



Projections of Industrial Electricity Demand

Between 2016 and 2022, the total industrial electricity consumption grew 3 percent annually. Of the total consumption, LT consumption contributed 56 percent of the total industrial electricity consumption and the rest was contributed from HT consumers and a marginal share from cottage industries.

Total electricity consumption from HT services, LT services as well cottage industries is expected to reach 185-200 GWh in 2050 from 133 GWh in 2022. Apart from Electricity, the industries also use fuel oil to run boilers and other thermal equipment. By assessing correlation between electricity consumption in the HT industries and fuel oil consumption, there is a high correlation observed ($R^2=0.67$).

Further, by using univariate regression, fuel oil demand was estimated to grow from 3.2 to 7.33 Thousand Metric Tonnes between 2022 and 2050, with associated GHG emissions increasing from 20 ktCO₂e to 47 ktCO₂e in the BCS scenario. With focus on alternate technologies like electric heaters, penetration of electricity is expected to meet industrial heating demand, thus the GHG emissions could be mitigated to reach 9 ktCO₂e under AES by 2050.

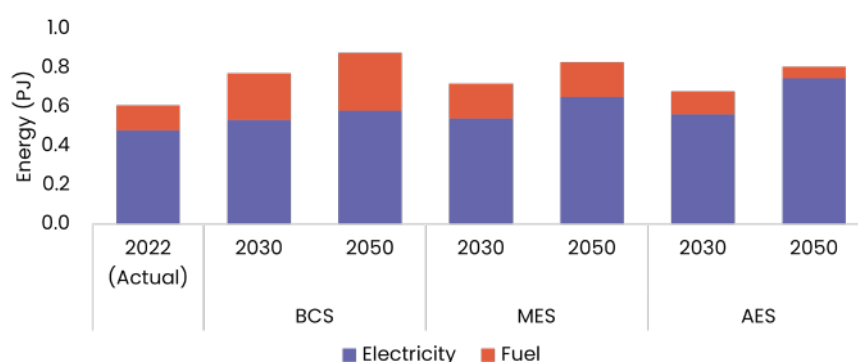


Figure 38(a): Aggregate energy requirement in industry sector

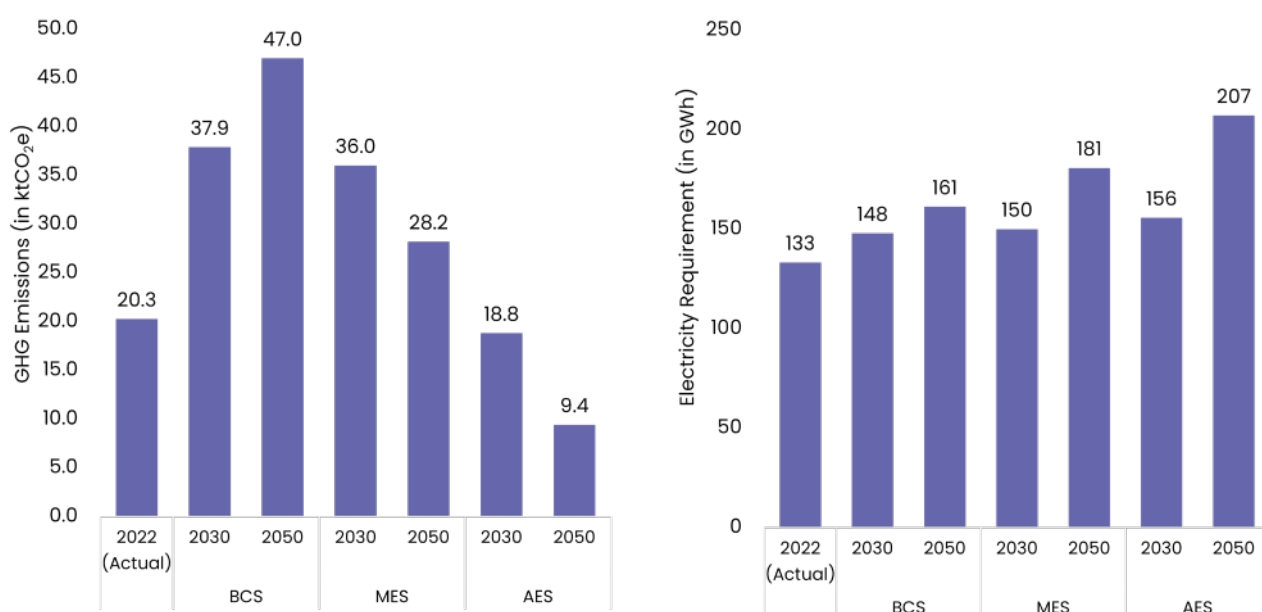


Figure 38 (b), (c): GHG emissions in the industry sector, aggregate electricity requirement in the industry sector



Indcoserve Kaikatty Tea Factory: Strategies for Decarbonising Production Processes

Established in 1965 by the Government of Tamil Nadu, Indcoserve stands as India's largest Tea Co-operative Federation, manufacturing about 13 million kgs of Black Tea annually and comprising 16 industrial tea factories, which engage approximately 30,000 small tea farmers across the Nilgiris District⁴⁴. Its comprehensive value chain encompasses sourcing green tea leaves from member growers, processing, distribution, and trading operations. Indcoserve plays a pivotal role in supporting small tea growers, facilitating their access to competitive markets and resources such as fertilisers and machinery spares. Through its extensive network, it markets a diverse range of tea products nationwide, including popular varieties such as 'Mountain Rose Tea', 'BlueMont Tea', and 'Ooty Tea', distributed in the market or through the Public Distribution System of Tamil Nadu.

We analysed the complete tea manufacturing process in the region and devised a comprehensive strategy for reducing carbon emissions within the manufacturing process of the Indcoserve Tea Cooperation, specifically focusing on utilising the Kaikatty Tea Factory as a pilot project. Various scenarios have been explored to identify effective measures for decarbonisation, supplemented by a thorough financial analysis to gauge the economic implications for the cooperation.

Following an exhaustive analysis, among the various suggested decarbonisation scenarios, the installation of a rooftop solar plant (125 kW) and a dedicated/captive ground-mounted solar plant (280 kW), along with waste wood-based air-heater, emerges as the most economically advantageous route amongst low-carbon options. This option, distinguished by its low levelised cost of electricity, proposes the installation of a solar captive system alongside the existing solar rooftop infrastructure, as opposed to procuring renewable electricity from external sources.

To achieve zero-carbon production at the Kaikatty unit, it may require the implementation of an electric air heater costing USD 32,000 which would result in heightened electricity consumption. Consequently, it necessitates the installation of a larger captive plant in anywhere in Tamil Nadu with a capacity of 2.5 MW, at a cost of USD 1.80 million.

This strategic choice not only harmonises with the factory's objectives to reduce carbon emissions but also presents a financially prudent trajectory, ensuring sustained operational sustainability. Furthermore, this solution holds the potential to serve as a blueprint for other tea factories within the Indcoserve Tea Cooperation.



Communities must be engaged in the sustainable decarbonisation of the tea industry in Nilgiris; civil society partnership can coordinate these efforts.

Tea industry in Nilgiris is a source of livelihood for 60,000 small tea growers and 1.2 million casual, seasonal and permanent workers in Nilgiris. A large proportion of these are women who pluck tea leaves, with some also engaged in tea processing. As Nilgiris decarbonise its tea industry, it is imperative that these community members, especially women, are engaged and made an equal stakeholder in the decarbonisation efforts. This could be done by leveraging the existing formal tea groups – including Self help groups (SHGs) – to own clean energy and energy efficient solutions.

Precedent for such an arrangement exists from pilots by civil society actors across States in India. The Telangana SHG Solar Power Initiative, for instance, engages SHG women to generate 1000 MW of solar power under the Indira Mahila Shakti Scheme, using 4,000 acres of land and interest free loans. In Bihar, women SHGs act as Irrigation Service Providers, by installing and managing operations of solar pumps. Solar Saheli Programme with pilots in Rajasthan, Uttar Pradesh, Bihar and Odisha, similarly, is an example of SHGs harnessed for deployment of energy solutions. Under this, SHG members are trained as solar entrepreneurs, selling and maintaining solar products for 550,000 households. Many more examples exist and can be replicated by Nilgiris to actively engage local communities in its decarbonisation efforts. This will ensure community ownership and promote a transition that leaves no one behind.

Policy Recommendations



01. Energy Efficiency in Tea Manufacturing

By 2030, implement rooftop solar and waste wood-based air heaters in 50 percent of tea manufacturing units, starting with pilot projects like Indcoserve's Kaikatty Tea Factory. By 2050, achieve full decarbonisation of tea production through electric air heaters and captive solar plants, with a focus on zero-carbon factories.



02. Electrification of Small & Medium Industries

By 2030: Electrify small and medium industries using renewable energy solutions like solar rooftop systems, reducing reliance on fuel oil. By 2050, ensure all industrial energy demand is met through renewable electricity, eliminating fuel oil consumption.

5.1.4 Buildings

Buildings constitute a significant portion of energy demand in the district's economy. In this study, the buildings category is divided into three major sectors: residential buildings, cooking (includes residential as well commercial cooking), commercial buildings and miscellaneous services.

Residential Sector

The residential sector is the predominant contributor to electricity consumption in the Nilgiris district. In 2022, the residential electricity demand stood at 198 GWh (46% of the total consumption), which grew 6.4% annually in the preceding six years, the fastest amongst all the categories. Residential appliance penetration in the households has high correlation with demographic parameters (population and households).

As per the census data, Nilgiris has witnessed a dwindling population between 2001 and 2021 (Source: Census 2011, DSHB 2021-22). The total population in the district fell from 7.6 lakh to 7.1 lakh during the same period, having previously grown at 1.5% annually over five decades until 2001. In addition to the absolute population decline, household population density, i.e., household size, also declined from 4.1 to 3.73 person per household between 2001 to 2011. This is similar to the trend observed in the Tamil Nadu state where a drastic reduction in total fertility rate has resulted in shrinking size of families, one of the lowest in the country⁴⁵.

It is estimated that the population in the district is expected to fall to 6.95 lakh by 2050, with a notable decline beginning in the late 2030s. Subsequently, the number of households in the district is expected to reach 2.16 lakh by 2050, experiencing positive growth compared with the population due to the trend of shrinking household size. In terms of demographic shift, there is a rise in urban population, with the urban population share shifting from 24 percent to 72 percent between 1901 and 2050. Therefore, the urban population may rise from 4.6 lakh to 5 lakh between 2021 to 2050.



Methodology for Projecting Electricity Demand in the Residential Sector

To assess the electricity demand projection by 2050, an appliance ownership model is employed to evaluate consumption across various electricity intensive and non-electricity intensive appliances in the households. To estimate the household appliance penetration, data from the Household Consumption Expenditure Survey 2011, NFHS Tamil Nadu report (FY 2015-16 and FY 2019-21) was used. For lighting devices such as incandescent bulbs, CFLs, CFL tubes, LEDs, and LED tubes, household penetration data was obtained from the India Residential Energy Survey (IRES)⁴⁶ of 2020. In the survey, data was not available for Nilgiris, so, the appliance penetration per household of the nearest district was considered. Further, operational parameters including hours, wattage were assumed based on secondary literature review⁴⁷.

Table 9: Overall residential appliance penetration (number per household) in Nilgiris in 2023 and 2050
(Source: Census,NFHS, NSSO, Authors Analysis)

Table 9 shows the appliance ownership across the residential households in 2023 and 2050 in the baseline scenario. It is observed that in line with current policies, the share of incandescent lighting reduces and its share is expected to be replaced by LED based point lighting. Meanwhile, demand for new appliances emerges in households as the consumption expenditure increases in the district. These utilities include heating, cooking and other kitchen appliances.

Appliance	2023	2050
Incandescent Bulb	1.35	1.35
CFL	0.92	0.92
LED	1.28	1.28
LED Tube	1.01	1.01
CFL Tube	0.97	0.97
Electric Fan	0.96	1.00
Refrigerator	0.68	0.89
Space Heater	0.47	1.00
Water Heater	0.51	0.67
Washing Machine	0.43	0.78
Microwave Oven	0.03	0.12

Across the scenarios, energy efficiency was projected assuming the current efficiency penetration mix in the appliances. The annual savings of appliances such as fans, refrigerators, space heaters, and washing machines, microwave ovens etc were computed from energy efficiency indicators (star labels) of various appliances. The baseline scenario assumes that all devices have baseline efficiency at current levels. In contrast, alternate scenarios with decarbonisation assume a higher level of efficiency with star-rated appliances.



Electricity Demand Projection from Residential Sector till 2050

Figure 39 shows the residential electricity consumption by appliance category in the BCS from current level to 2050. Overall, electricity consumption is expected to rise to 288 GWh by 2050 in the BCS, growing 1.5% annually. A moderate growth is expected to be observed in the residential appliances from 2040, given a decline in the residential population. Appliance usage (refrigerators, washing machines, fans, electric motors) contributes to 42 percent of electricity consumption, followed by lighting at 35 percent, and heating (space heating and water heating) at 23 percent. Improvements in energy efficiency of appliances are expected to reduce overall electricity consumption and energy related emissions. However, the electricity demand for heating will increase significantly. Similarly, the electricity demand for lighting and other appliances will also rise, albeit at a moderate pace.

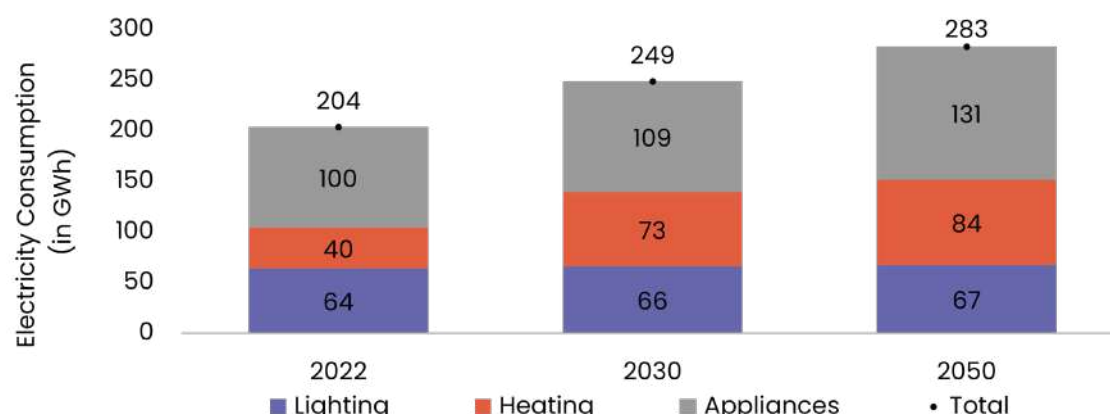


Figure 39: Residential electricity consumption (GWh) by category in the BCS

Cooking Sector

Cooking sector consumes a substantial portion of residential energy use, given that cooking constitutes ~60 percent of the residential Indian households' energy demand⁴⁸ and is a potential source of emissions from solid and liquid fuels. Between 2006 and 2023, LPG sales (domestic and commercial combined) in the district have almost grown by 4 percent annually to 21 thousand metric tons (Source: PPAC). The Demographic and Health Surveys (DHS) meta-analysis showed that in the Nilgiris, 25–30 percent of households still relied on solid cooking fuel in FY 2015–16⁴⁹. With limited quantitative evidence of a cooking preference in the Nilgiris district, multiple secondary data through district Census, NFHS and IRES were referred to identify the cooking fuel preference in households as well as the commercial segment. This enabled to assess the changing fuel consumption share over the years. Thus, cooking demand is forecasted across both residential and commercial segments in the district.

While the reach of the UJJWALA scheme has enabled access of LPG to many households, these households often avail multiple sources of fuel for cooking. Therefore, it is important to establish a composite fuel penetration across households which has been considered in this study for projections.



Methodology for Projecting Cooking Demand till 2050

To project remove cooking energy demand, primary heat requirement and associated energy demand at final end use level was assessed. To estimate the final cooking energy consumption (i.e. energy that effectively contributes to cooking minus losses), useful energy (UE) was selected as a metric to calculate cooking energy requirement per capita. The cook stove thermal efficiency was used to estimate the primary energy requirement and forecast the same under different scenarios till 2050. Figure 40 shows the current level of cooking fuel and projected demand between 2022 and 2050. It is observed that the growth of cooking fuel demand is very slow for the residential sector and tapers slightly towards mid-century, given a slowdown in population and subsequently the energy consumed by households.



Cooking Demand Projections

Thereby, the final consumption of cooking energy is expected to reduce from 3.1 GJ/household to 2.54 GJ/household between 2021 to 2050 with an observable reduction in household size, especially given the demographic trend observed in Tamil Nadu⁵⁰. In terms of LPG based cooking, the demand is expected to increase from 1.2 PJ to 1.3 PJ between 2022 and 2050. This rise can be attributed to the growth in commercial tourist footfall in the region (725 Hotels in the district). With demand for tourism high in the district, the demand for commercial cooking and thus, LPG consumption would grow faster. Whereas, in the decarbonisation scenario, share of electricity in cooking energy demand increases substantially, its share rising from 2 percent in BCS to 56 percent in AES in 2050.

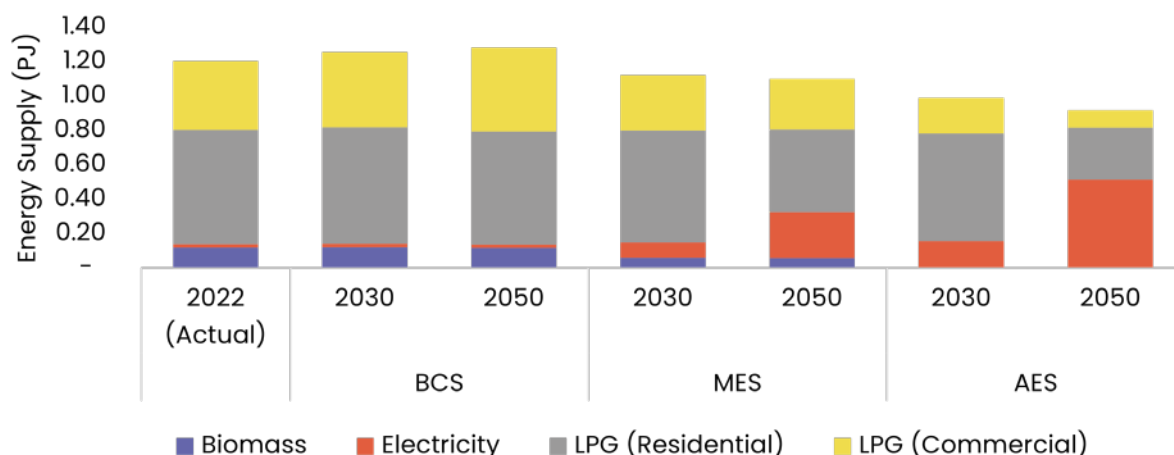


Figure 40: Cooking energy demand (GJ) in the district

Commercial Buildings, Water Works and Public Lighting

Commercial Buildings and Water Works

Commercial buildings in the district include buildings like hotels, places of worship and educational institutes. In FY 2022-23, electricity consumption combined from buildings and water works stood at 86 GWh, of which buildings comprised 77 percent of the total consumption. This is likely given the huge tourist footfall in the district where much of this electricity demand is for heating and lighting in the buildings.

It is anticipated that the consumption will rise to 146 GWh with the fastest growth observed in the institutions and commercial buildings (~4%). Apart from electricity, commercial buildings especially hotels in the Nilgiris are a notable consumer of diesel for power backup services. It is estimated that the diesel consumption in the commercial buildings for the purpose of diesel generator sets could rise to 2.2 TMT to 5.2 TMT between 2022 and 2050.

Public Lighting

The consumption of electricity for public lighting services in the district grew ~8 percent to 11 GWh between 2016 and 2023. With a lack of clarity on the number of streetlights in the district and distribution of LED and sodium vapor lamps in the district, an empirical evidence-based analysis was conducted. The district serves a roadways network consisting of 1572 Km of surfaced road and 328 Km of unsurfaced road (Source: District Statistical Handbook). By considering of increased access of street lighting, total stock of street lighting was derived. It is thus estimated that the street lighting stock could increase to 1.41 Lakh and aggregate consumption to 19.5 GWh by 2050. It is important to note that replacement of sodium vapor lamps to LEDs could drastically reduce the electricity consumption and thus a reduction of ~2.7 GWh could be achieved due energy efficient lighting fixtures.

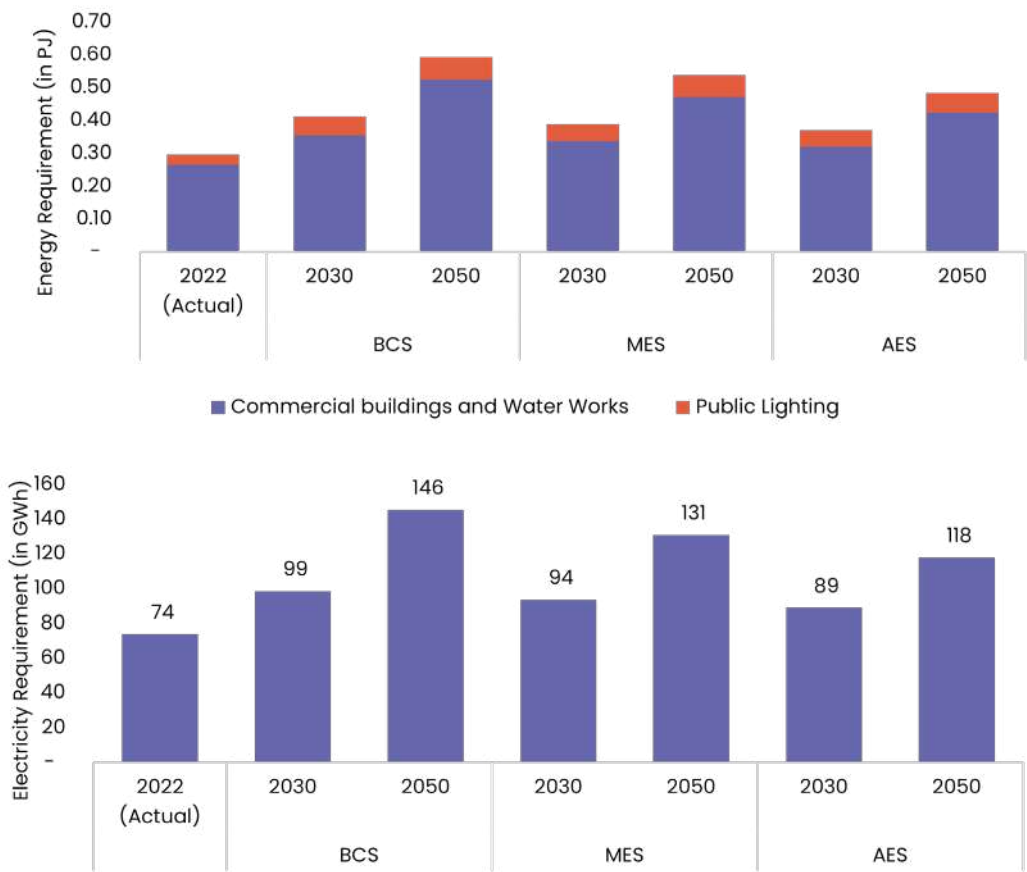


Figure 41(a), (b): Electricity consumption in commercial buildings and other services by 2050, energy supply in the commercial buildings and other services by 2050

Aggregate Results of Buildings

Energy supply from buildings with current pace is expected to grow to 2.5 PJ by 2050. Thus, forming a third of the total energy supply in the district. However, with energy efficiency in building appliances and fuel switching in diesel generator backup and cooking fuel, significant fuel saving is anticipated. In AES scenario, energy supply nearly falls back to current levels given the efficiency gains. In AES, the total energy supply for electricity grows by nearly 50 percent by 2050 signalling a shift away from conventional fuels. Thereby, emissions falls sharply in the AES as electric based cooking and diesel fuel brings down emission by 65% compared to BCS to 29 ktCO₂e.

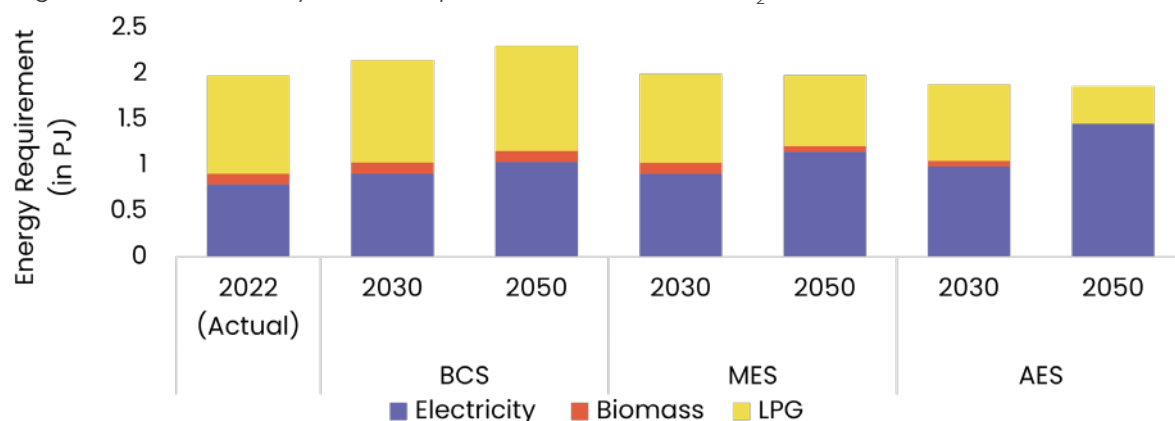


Figure 42 (a): Aggregate energy requirement in the buildings sector

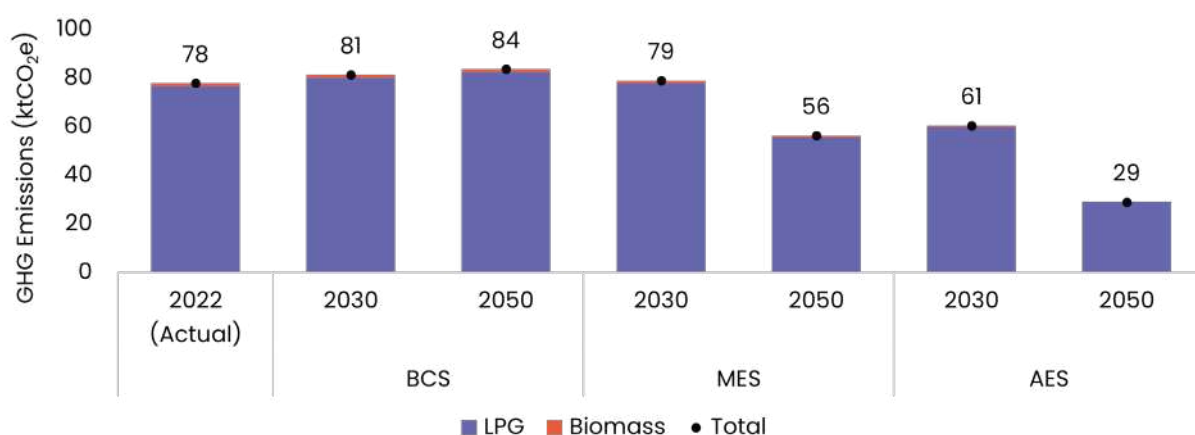


Figure 42 (b): GHG emissions in the buildings sector

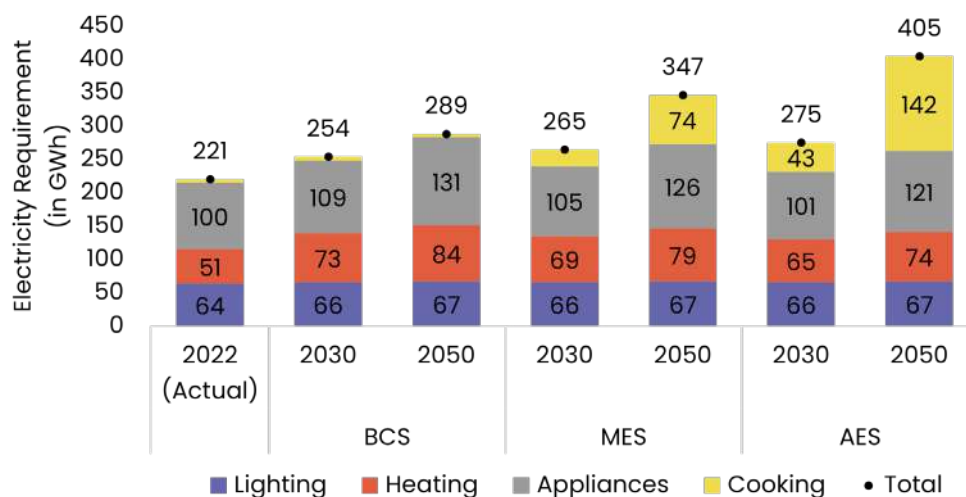


Figure 42 (c): Aggregate electricity requirement in the buildings sector



Electric heating solutions at single household and community level can abate cooking and space heating emissions in Nilgiris while delivering other environmental and health co-benefits

Firewood is one of the most common energy sources for space heating and cooking in Nilgiris. The rural households in Nilgiris are dependent upon firewood and chips as the main fuel for cooking – doubling also as a source for space heat in small hilly accommodations.

By shifting from firewood to electric heating for cooking and space heating purposes, Nilgiris can reap three-pronged benefits of emission abatement, reduction in tree cutting for firewood, and health co-benefits as electric cook stoves and heaters replace soot from firewood burning – which is a respiratory hazard. Considering that this reliance is more pronounced in lowest income communities (spending less than Rs. 2,042 per person on monthly consumption), where the share of households using firewood and chips as main fuel is as high as 95% – this also becomes a moral imperative for the State.



Heat Pumps in Nilgiris: A Smart Investment for Hotels, a Costly Choice for Homes

In the temperate climes of the Nilgiri hills, where the demand for hot water and space heating is year-around reality for commercial buildings, the adoption of heat pump technology presents a compelling case for energy savings and cost benefits. For high-space heating and hot water demand sectors in Nilgiri like hotels and hospitals, the switch to heat pumps is a clear pathway to operational efficiency and reduced carbon footprint. For hotels and hospitals in popular destinations like Ooty and Coonoor, the constant requirement for large volumes of hot water for bathing, laundry, and sanitation, coupled with the need for space heating during the cooler months of December-January-February when the temperature ranges from 14°C to 19°C, with January being the coldest month. This makes energy needs for heating a significant operational expenditure.

Heat pumps, which extract heat from the ambient air and transfer it to water/air, offer a highly efficient alternative to conventional electric or fossil fuel (fuelwood) based boilers/air heaters. With a Coefficient of Performance (COP) often ranging from 3 to 4, a heat pump can deliver 3 to 4 units of heat energy for every single unit of electricity consumed. This is a stark contrast to direct electric heaters, which have a COP of 1.

High-Payoff Gap: While heat-pumps offer an effective means of reducing heat related emissions, it is not a one-stop solution for homes and commercial/service establishments alike. There is a significant upfront cost involved for setting up heat-pumps. In commercial/service establishments, a heat pump set-up of 1500 litre/day capacity will incur an average capital cost of INR 4,50,000 and installation cost of INR 25,000. The payback period is, however, less than 2 years. In comparison, in domestic households, a heat-pump setup of a 50-100 litre/day capacity, with capital cost of INR 60,000 and Installation cost of INR 5,000, the payback period could be more than 10-12 years due to limited or purely seasonal usage, making it comparatively less lucrative than a standard direct electric heater.

Policy Recommendations

Energy Efficient Appliances

Adopt 0.6 lakh 3/5 star water heaters, 0.24 lakh 3/5 star space heaters, 1.2 lakh 3/5 star refrigeration units and 3.5 lakh BLDC fans through incentives and subsidies. National Energy Efficient Fans Program (EEFP) and National efficient cooking programme (NECP) could be utilised to ensure mass adoption of 5 star appliances.

Increase Renewable Energy Integration in Buildings

Increase penetration of rooftop solar by 30% in residential buildings by 2050. This could be availed through national PM Surya Ghar Scheme and similar subsidies allocated through Tamil Nadu State Government for Commercial Setup.

Mandate Energy Efficiency Retrofits for Hotels and Institutions

Introduce mandatory energy efficiency standards for commercial buildings, focusing on hotels, institutions. Retrofitting should include installing energy-efficient heating, ventilation, and air conditioning (HVAC) systems, high-performance windows, and LED lighting.

Phasing Out Diesel Generators with Solar-Backup Hybrid Systems

Start the phased transition from diesel generators to hybrid backup systems incorporating battery storage and solar power in hotels and commercial establishments. Introduce financial support mechanisms like low-interest loans for building owners to install solar-battery backup systems.

Accelerate the Transition to LED Street Lighting across the District

Implement a district-wide program to replace all existing sodium vapor lamps with ~1.07 lakh LED streetlights, covering both surfaced and unsurfaced roads. This could be further coupled with a solar integrated smart system. This can be coupled with smart street lighting systems to allow dimming during low traffic hours, optimising energy use.

Accelerate Transition from Solid Fuels to LPG and Electric Cooking

Transition ~50 percent of households from LPG to electric cooking, using efficient induction stoves powered by renewable energy, achieving a fully sustainable cooking sector with no solid fuel reliance.

Promote Clean Cooking Solutions in the Tourism and Hospitality Sector

Introduce policies that mandate the use of clean energy (Electricity) for commercial cooking in hotels and restaurants, aiming to replace inefficient solid-fuel and LPG in the commercial sector.

5.2 Aggregate Results across the Scenarios

5.2.1 Electricity

Electricity consumption is expected to rise from 424 GWh in 2022 to 622 GWh in BSC 2050. Through partial and deep electrification across energy sectors, this may further rise to 711 GWh in MES 2050 and 865 GWh in AES 2050. In 2022, the domestic sector was the largest consumer, constituting 46 percent of the total consumption at 198 GWh. However, by 2050, it is expected that the share of electricity amongst sector might change. Where the domestic sector's share could remain almost equal, transport sector is expected to grow fastest by 2050, with its share increasing from 4 percent to 15 percent between 2022 and 2050. On the other hand, LT and HT industries could see a marginal decline, with uptake of energy efficiency and fuel switching.

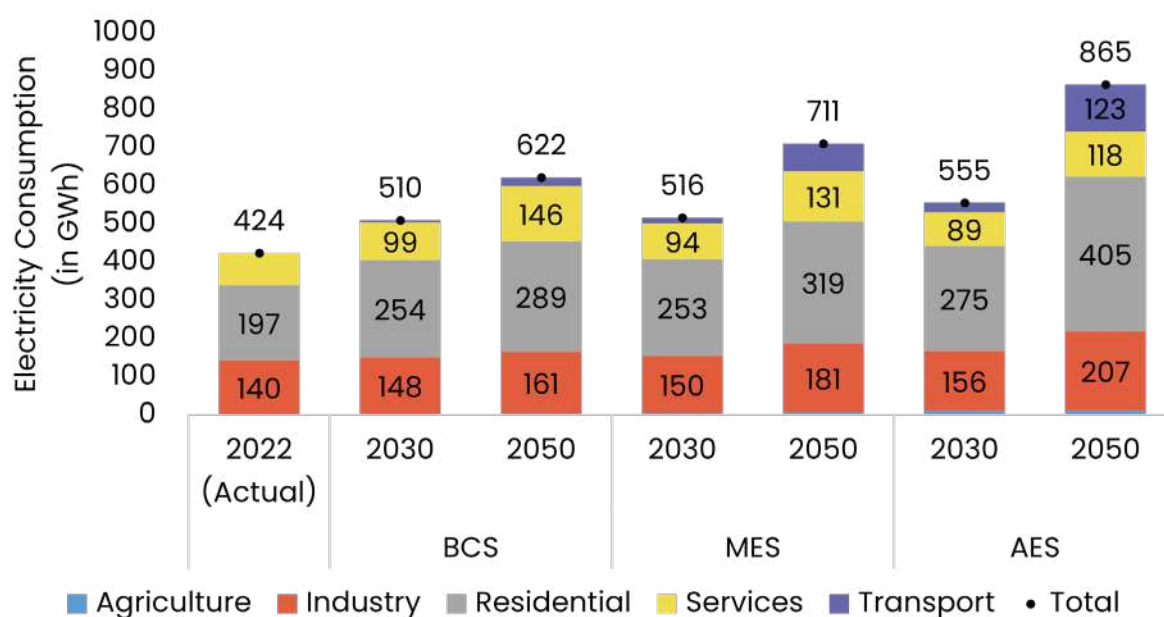


Figure 43 : Nilgiris electricity requirement (In GWh) projections by 2050 in the BCS

5.2.2 Total Primary Energy Supply (TPES)

TPES refers to the overall energy consumption by the end users (residential, commercial, transport, industry etc) plus system efficiency losses in conversion. Figure 44 shows the TPES by constituent fuels. It is projected that the TPES could grow to 6.3 PJ by 2050 in the BCS scenario. Road Transport holds a predominant share in the total energy supply of the Nilgiris, contributing to almost half of the total energy requirement. The residential sector follows after the transport sector, being a significant consumer of electricity (~23%) in the district, predominantly for lighting and space heating use. With higher share of fleet electrification, it is expected that energy supply could fall to 4.4 PJ, owing to efficiency improvement gains from electrification. Thus, the share of electricity is expected to increase from 34 percent (currently) to 60 percent in 2050.

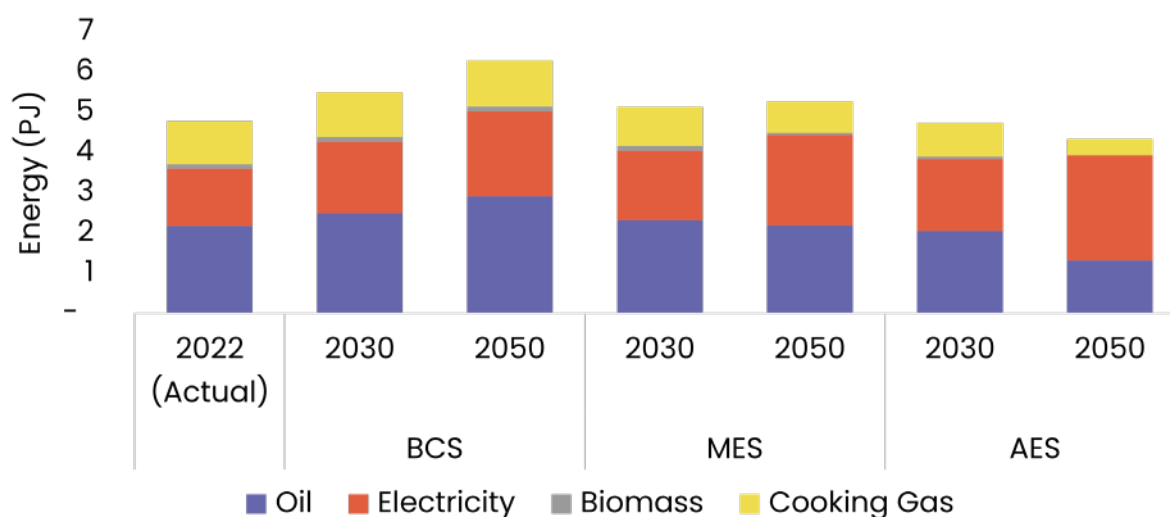


Figure 44: Total primary energy supply projections between 2022 and 2050

5.2.3 GHG Emissions from Energy Sector

Figure 45 shows the total energy sector emissions projections up to 2050. It is thus projected that the gross energy sector GHG emissions could grow two-folds to 332 ktCO₂e by 2050. In 2020, the total energy emissions amount to 252 ktCO₂e, with the transport sector as the primary contributor at 145 ktCO₂e. By 2025, the transport sector is expected to experience a steady growth, with emissions growing by approximately 30 percent, reaching 189 ktCO₂e by 2050. Similarly, emissions from the building sector, which account for 31% of energy emissions in 2022 and is expected to continue as the second highest emitter in the energy sector in 2050 too, can be reduced by 65% from BCS 2050 through adoption of clean cooking and energy efficient solutions. Industrial emissions, standing at 20 ktCO₂e in 2022, are expected to rise to 47 ktCO₂e by 2050. As much as 80% of these emissions can be curtailed through electrification of heating processes, particularly in the tea industry of Nilgiris. With decarbonisation measures in place, ~57% of energy emissions can be abated, with remaining 142 ktCO₂e in AES 2050.

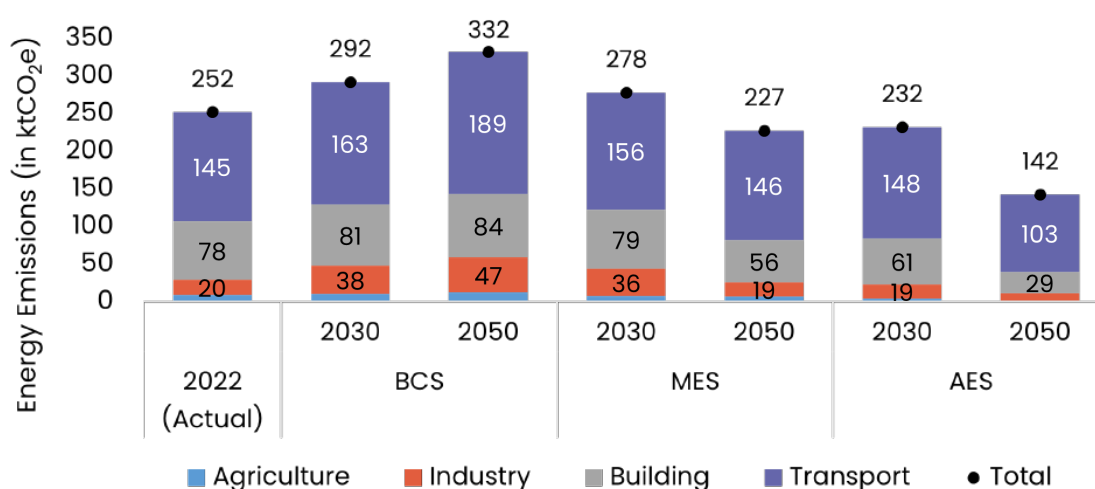


Figure 45: Energy sector GHG emissions projections till 2050

Electricity Generation in the District

Electricity Generation in the district comprises reservoir hydro generation. The hydro generation exceeds ~5 times of the total electricity consumption of the district. This provides an opportunity for power trade across the states and region. Therefore, considering GHG emission from power generation, the district is already carbon net negative. The generation through the past 6 years has varied between 2096–2363 GWh, except for the drought year in 2016–17, which reduced the generation to more than half. The hydro generation in the coming decades is expected to rise. This is due to two reasons as cited from the analysis. First, the southwest monsoon rainfall is projected to increase by 23 percent to 46 percent under RCP 4.5 and RCP 8.5 emission scenarios. Second, the winter monsoon precipitation also increases by 3 percent to 35 percent under RCP4.5 and RCP 8.5 emission scenarios, and the rainy days increase in response to global warming.



5.3 Projection of Emissions from Non-energy Sectors

5.3.1 Waste Sector



Solid Waste Disposal

The GHG emissions from the solid waste are projected to remain at 2022 levels of ~1.9 ktCO₂e. This can be attributed to the efficient management of solid waste. The Nilgiris District currently has nearly 100 percent of door to door collection and 98.34% of source segregation of municipal solid waste. Further, the district has banned the use of single use plastics.⁵¹ The district could also benefit from remediating the legacy waste from landfills and open dumping.

Policy Recommendations for Efficient Solid Waste Management



ULB Level Waste Management

- Encourage 100% segregation and collection of waste at source.
- Set up dry waste collecting centers at village/panchayat level.
- Incentivise dry waste collection.
- Promote resource utilization through reuse, recycle and recovery.



Tourism Industry Waste Management

- Facilitate dry and wet waste bin placement, collection and management of waste in strategic tourist locations.
- Promote Deposit Refund System (tax on the product consumed and reimbursed when product is returned) for managing plastic waste at places such as National Park, Botanical Gardens, lakes etc.
- Facilitate and conduct "Sustainable Consumption" awareness and also the concept of "Responsible Tourism".
- Appropriate sign boards, surveillance and penalty to avoid littering.



Open Dumping

- Surveillance and penalty for violators.
- Put alternate waste management systems
- Install community waste bins with sensors to monitor volume and optimize routes of waste collection vehicles.
- Incentivise the informal sector and build public-private partnerships for proper segregation, collection and disposal of waste.
- Encourage and promote composting, vermi-composting and biogas plants at residential and commercial entities (hotels/resorts/homestays).
- Facilitate and conduct Behaviour Change Communications workshops on proper disposal of solid waste.



Circular Economy

- Establish Material Recovery Facility for maximum resource recovery and preventing it from going to landfill.
- Encourage eco-design of products that allows repair, reuse and recycling of products.
- Promote and encourage eco-labelling of products for consumer awareness.
- The non-recyclable waste can be used to generate energy in the form of steam or electricity using the Waste to Energy approach.
- Create a market for industries and enterprises for accessing recovered resources/raw materials for the production.
- Introduce and strengthen Extended Producer Responsibility guidelines for Plastic and e-waste management.

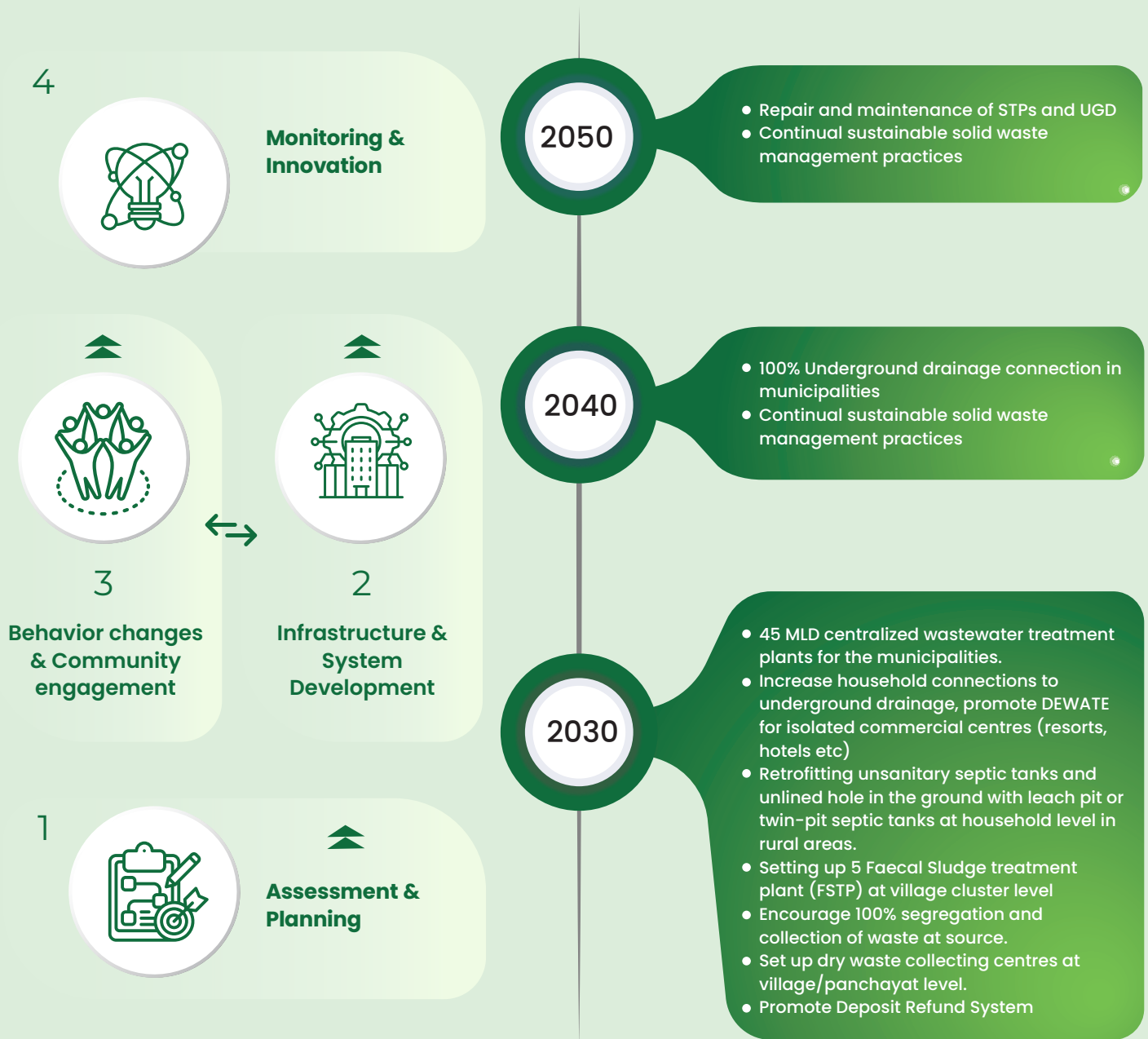


Other Recommendations

- Promote Biomining of legacy waste at the administrative level.
- Facilitate cleaning of dumpsites and encourage development of eco parks.
- Promote zero waste, zero carbon footprint, organic thematic centers (restaurants/ home stays)

Road Map: Waste Management

The Nilgiris District, faces significant challenges in solid waste and wastewater management due to rapid urbanisation, tourism and overstressed infrastructure



Best Practices in addition to existing system

- Ban on Single-Use Plastics –Strict implementation of local plastic bans in tourist zones like Ooty and Coonoor.
- Tourist Waste Control Mechanisms – Set up designated disposal and awareness systems at viewpoints and parks.
- E-waste Collection Drives – Organize periodic drives in schools, offices, and hotels in urban centers.
- Plastic Buy-Back Centres – Incentivize return of plastic waste in local heats and weekly markets.
- Promote Waste-Based Enterprises – Support startups in upcycling, composting, and plastic reuse.
- Clearing Legacy Dumpsites – Bioremediate old dumps in Udhagamandalam and Gudalur municipalities.



Domestic Wastewater Treatment and Discharge

The wastewater emissions estimations comprise wastewater from municipal households; academic and government institutions; and commercial establishments such as restaurants, hotels and other tourist homes. The emissions from domestic wastewater are projected to decrease by ~6 percent from 34 ktCO₂e in 2022 to 32 ktCO₂e by 2050 in BCS. The decrease in GHG emissions is due to a decrease in population (see Figure 46). The contribution of urban and rural populations to the total GHG emissions is projected to remain at ~73 percent and 27 percent, respectively.

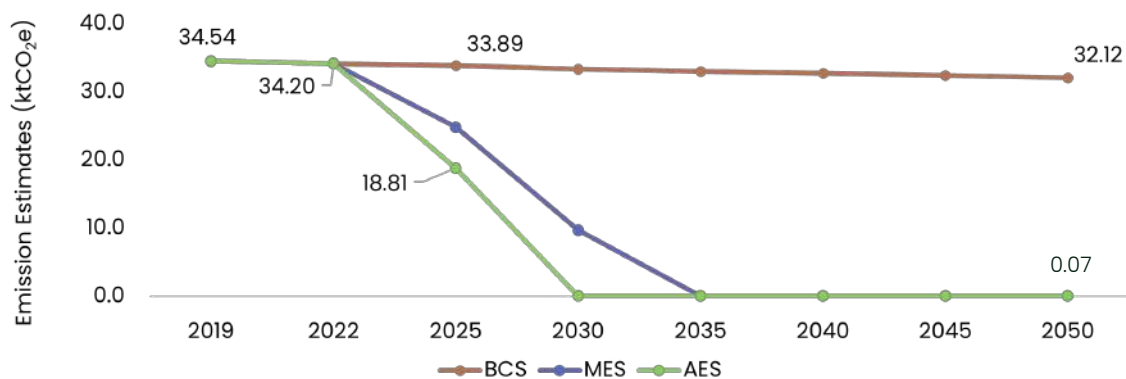


Figure 46: Projected GHG emissions from domestic wastewater under various scenarios

As of May 2025, there is one operational STP in the district at Ooty with a treatment capacity of 5 MLD (utilized at 4.5 MLD) and a fully utilized 10 KLD FSTP at Coonoor, with another 20 KLD FSTP under construction in Gudalur⁵². Considering the district's large tourist-related floating population and the resulting wastewater load, a 45 MLD centralized treatment facility for urban centers is recommended, along with twin-pit septic tanks at the household level, FSTPs at Gram Panchayat cluster level for rural areas, and DEWATS for isolated commercial establishments such as resorts and homestays.⁵³ The plan targets 100% wastewater treatment by 2035 under the MES and by 2030 under the AES (refer to Annexure 5 for details).

While the district's hilly terrain poses challenges for large-scale STP development, such facilities are essential in dense urban centers like Ooty and other growing towns to prevent water contamination and protect public health. At the same time, decentralized and nature-based wastewater solutions—such as constructed wetlands, reed-bed systems, and vegetation-based filtration models—offer practical and sustainable alternatives better suited to the district's terrain and high rainfall conditions.

The emissions from the domestic wastewater category could plummet from 32.12 ktCO₂e to <5 ktCO₂e through policy recommendations for wastewater treatment and management measures enlisted below.

Policy Recommendations for Water and Wastewater Management

1. Ensure that untreated wastewater is not discharged into rivers/lakes and other water bodies (Kallar, Moyar rivers; Sandynulla, Ooty and Pykara lakes)
2. Periodic scouting of the water body periphery to check the discharge of untreated wastewater and penalising the violators.
3. Marking and bund construction around the boundaries of the water bodies.
4. Water taxing to control over usage of water by the tourism focused commercial entities.
5. Zero discharge policy for commercial and residential entities in the township boundary.
6. Promote non-potable usage of treated wastewater (gardening, parks, golf courses, car wash).
7. Regular water quality testing and monitoring to ensure the treatment standards
8. Regulations for the use of treated water discharged from the STPs.



Reviving Ooty's Wetland Heritage

The lakes of Ooty, including Ooty Lake, Ketti Valley Marshes, Pykara Lake, Avalanche Lake, and Emerald Lake form a vital part of the Nilgiris' high-altitude wetland ecosystem. These water bodies regulate microclimate, recharge groundwater, harbor endemic biodiversity, and serve as carbon sinks.

Wetlands like the Kamaraj Sagar Dam catchment and Mukurthi National Park marshes are also critical habitats for migratory birds and endangered species such as the Nilgiri Tahr and Indian elephant. Additionally, these ecosystems support eco-tourism, fishing, agriculture, and water provisioning to Ooty and surrounding towns.



Current Challenges:

- Encroachment from unregulated urban expansion, housing, and infrastructure
- Pollution from solid waste, sewage, and agricultural runoff (fertilisers, pesticides)
- Siltation and Eutrophication due to upstream deforestation and untreated greywater inflows
- Loss of native marsh vegetation and invasion of alien species like Lantana and Eichhornia
- Climate change impacts altered monsoon patterns, and drying wetlands

Ooty Lake, once a pristine highland reservoir, now faces high turbidity and algae blooms, impacting both aesthetics and aquatic biodiversity.

Sustainable Revitalization of Ooty Lake & Eco-Tourism Promotion

Ecological Restoration

- Prevent sewage inflow via DEWATS and sewer upgrades.
- De-silt lake and remove invasive species like water hyacinth.
- Reforest catchment with native flora for bank stabilization and recharge.

Eco-Tourism Infrastructure

- Promote electric/pedal boats, eco-trails, and green-certified amenities.
- Cap visitor numbers and boat trips based on carrying capacity.
- Establish an eco-education centre and nature-guided tours.

Community Participation

- Form a local lake management committee.
- Train locals as eco-guides; support SHGs for eco-souvenir stalls.

Policy & Finance

- Enforce lake buffer and tourism code of conduct.
- Monitor water quality; fund through CSR, green surcharges, and PPPs.

5.3.2 AFOLU Sector

The gross emissions of the AFOLU sector (excluding the Land sub-sector) are projected to increase from 46 ktCO₂e in 2022 to 81 ktCO₂e in 2050. The Livestock and Agriculture Soils were the major contributing categories to the total gross emissions of the AFOLU sector (excluding the Land sector) in 2022. The projected increase in emissions is attributed to the increase in the projected fertiliser consumption between 2022 and 2050.



Agriculture Soils

GHG emissions are projected to increase 3.5 times from 21 ktCO₂e in 2022 to 72 ktCO₂e in 2050, due to the projected increase in Nitrogen fertiliser consumption from 7 kt in 2022 to 24 kt in 2050, and Urea consumption increasing from 6 kt in 2022 to 13 kt in 2050 (see Annexure 4 for assumptions used for projections).

Substitution of organic fertilisers and nano urea could significantly reduce the GHG emissions arising from the use of synthetic fertilisers. Nano fertiliser⁵⁴ has the potential to regulate the release of nitrogen (N) for an extended period (20 days) compared to the conventional urea fertiliser (9 days). The slow and steady release of nitrogen assists in the reduction of nitrous oxide emissions by 50 percent in nano-fertiliser fertilised soils.⁵⁵

The adoption of organic farming practices can not only decrease GHG emissions but can increase yield over the long-term. Shift to organic farming can contribute significantly towards the improvement of soil health by increasing soil nutrient mineralisation, microorganism abundance, diversity as well as soil physical properties. Farmer support including strengthened extension services with easy access to inputs, together with the development of robust markets for organic produce, certification and branding is recommended, to incentivise farmers to adopt organic farming.⁵⁶

The organic fertiliser and nano urea substitution for MES and AES is described in Annexure 5. By 2050, in MES, 50 percent of total nitrogen and urea could be replaced by organic fertiliser and the remaining urea requirement could be met through nano urea. Emissions are anticipated to decrease by 50 percent from 72 ktCO₂e in BCS to 36 ktCO₂e in 2050. In AES, 75 percent of the total nitrogen and urea will be replaced by organic fertiliser and the remaining urea requirement is met with nano urea by 2050. Emissions are anticipated to decrease from 72 ktCO₂e to 18 ktCO₂e in 2050 (Figure 47).

The application of nano urea, organic fertilisers and other innovative bio-products is especially suitable for the Nilgiris district, which is acclaimed for the cultivation of exotic fruits (mangosteen, passion fruit, peach, pear, rambutan, strawberry, etc) and vegetables (cabbages, carrots, Brussels sprouts, French beans and lettuces) that are high-value products grown in controlled and monitored conditions.

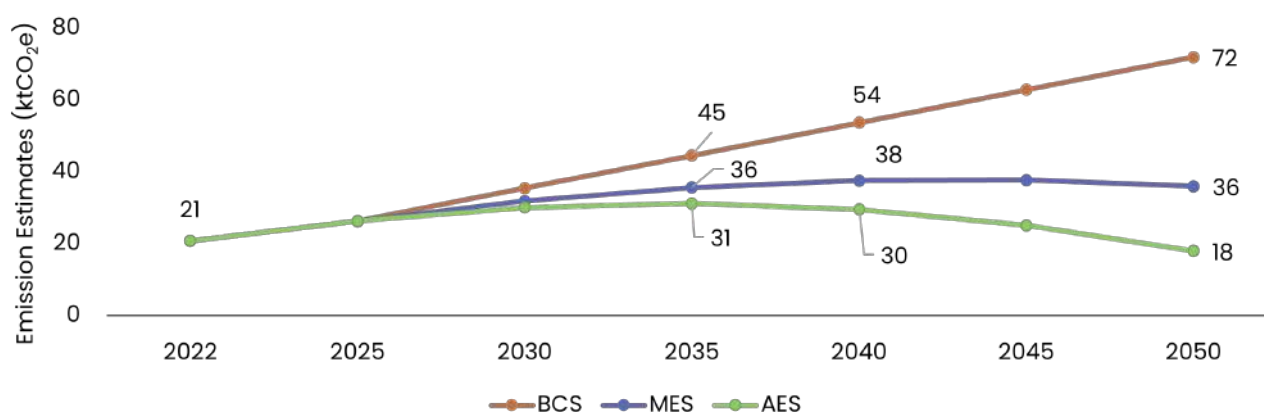


Figure 47: Projected GHG emissions from agriculture soils under various scenarios

In addition, it is also recommended to:

- Promote and encourage use of bio-pesticides and 'zero budget natural farming' practices.
- Encourage use of decision support tools for effective input/nutrient management.



Rice Cultivation

The emissions from rice cultivation declined rapidly from 3 ktCO₂e in 2005 to 0.21 ktCO₂e in 2022, since the area under cultivation decreased from 1433 Ha in 2005 to 115 Ha in 2022. Accordingly, the GHG emissions from rice cultivation are projected to be negligible by 2050.



Livestock

In Nilgiris, goat rearing is particularly prevalent in the livestock sector. According to 2019 livestock census figures, of the total livestock population of 69,757, 43 percent were cattle and 49 percent were goats. The cattle population declined by 49 percent from 50,768 in 2012 to 29,982 in 2019. The decline could be attributed to a decrease in pastures, grassland and other grazing areas, as well as shortages of fodder and restrictions on accessing forest areas.

The GHG emissions from the livestock category in 2022 were ~24.7 ktCO₂eq, of which enteric fermentation contributed 92 percent, and 8 percent came from manure management. GHG emissions from livestock are projected to decline to 9.2 ktCO₂e by 2050, attributed to the declining cattle count (see Annexure 4 for assumptions).

Although the GHG emissions from the livestock category are minute, the use of improved feed supplements can be encouraged to further decrease emissions. ICAR-National Institute of Animal Nutrition and Physiology has developed a feed supplement – Harit Dhara and Tamarin Plus, for cattle, buffalo and sheep, which is effective in cutting down enteric methane emissions by 20 percent⁵⁷.



Biomass Burning in Cropland

The emissions due to biomass burning in cropland have steeply declined from 47 tCO₂e in 2005 to 4 tCO₂e in 2022 since the area under cultivation has decreased. For example, the production of rice reduced from 4727 tonnes in 2005 to 491 tonnes in 2022, and sugarcane production reduced from 1166 tonnes in 2005 to 47 tonnes in 2022. Accordingly, the emission projections from the cropland biomass burning are projected to be negligible in the long term.



Sustainable Farming Practices

- Agricultural practices such as mixed cropping and multi layer cropping can be adopted to optimise/maximise agricultural output.
- Capacity building programmes can be conducted through Krishi Vigyan Kendra for creating awareness on climate resilient practices.
- Local network of mini weather monitoring stations can be established to monitor rainfall and temperature as well as to be able to forecast extreme weather conditions. This can help inform farmers of appropriate sowing, harvesting and irrigation timings.

Road Map - Sustainable Agriculture

Agriculture in the Nilgiris district, with a net sown area of 72,265.679 hectares, is shaped by its high-altitude climate, hilly terrain, and rich biodiversity. Key crops include tea, exotic fruits and vegetables, spices, often grown through terrace and mixed farming.

4



**Monitoring,
Evaluation &
Innovation**

3



**Capacity Building
& Sustainable
Practice**

2



**Policy Support &
Infrastructure**

1



**Baseline
Assessment &
Community**

2050

- 54,199 Ha (75%) net sown area transitioned to organic fertilizer; remaining 13% urea demand met via nano urea.
- Climate-resilient practices promoted through capacity building programs.
- Balanced rationing implemented for 9,223 cattle (90%); improved feed supplements for 7,686 cattle (759%).
- 90% manure managed to avoid methane emissions.

2040

- 32,520 Ha (45%) net sown area transitioned to organic fertilizer; 28% urea demand met via nano urea.
- Climate-resilient practices promoted through capacity building programs.
- Balanced rationing implemented for 9,883 cattle (60%); improved feed supplements for 8,236 cattle (50%).
- 90% manure managed to avoid methane emissions.

2030

- 10,840 Ha (15%) of net sown area transitioned to organic fertilizer; 15% urea demand met via nano urea.
- ~800 number of Solar Pump sets to be installed to replace inefficient pump sets
- Climate-resilient practices promoted through capacity building programs.
- 15 local mini weather stations set up for real-time monitoring and extreme weather forecasting.
- Balanced rationing adopted for 6,436 cattle (30%); improved feed supplements for 5,363 cattle (25%).
- 30% manure managed to avoid methane emissions.



Best Practices in addition to existing system

- **Rainwater Harvesting & Micro-Irrigation:** To optimize water use in hilly areas.
- **Crop Diversification:** Encourage mixed and intercropping to enhance resilience and soil health.
- **Climate-Resilient Crop Varieties:** Promote drought- and flood-tolerant seeds to adapt to changing climate.
- **Agroforestry and Tree Plantation:** Integrate trees with crops to improve biodiversity and soil stability.
- **Soil Health Management:** Regular soil testing and use of compost to high soil organic carbon.
- **Zero Tillage and Mulching:** Reduce soil disturbance and conserve moisture.
- **Farmer Training & Capacity Building:** Conduct regular awareness programs on sustainable techniques.
- **Contour Farming:** Align crops along slopes to prevent erosion.
- **Precision Agriculture:** Use sensors and data to optimize farm inputs, especially for high value crops.
- **Vermicomposting:** Recycle organic waste into nutrient-rich compost.
- **Crop Rotation:** Alternate crops to improve soil and reduce pests.
- **Protected Cultivation:** Grow high-value crops in polyhouses year-round.

5.4 Carbon Sequestration Opportunities

The Nilgiris, characterized by its rich forest ecosystems and grasslands, currently functions as a substantial carbon sink, sequestering 323 ktCO₂e per year. Ongoing restoration initiatives—such as the slope restoration initiative by the Collectorate, CSR-supported Craigmere Tea Estate interventions, and TN-CARD invasive species removal—are contributing to maintaining and enhancing this sink. To further strengthen natural carbon sequestration, additional targeted interventions, including agroforestry expansion, shola grassland restoration, and enhancement of carbon stock density, are proposed, with the potential to sequester an additional 174 ktCO₂e annually by 2050 under the aggressive scenario.

Promoting Social and Agroforestry

A total of 24,245 hectares of land is classified as non-agricultural use, barren and unculturable land, other fallow land, and current fallow land making up 10% of the total geographical area. These areas hold huge potential for carbon sequestration if developed as social forests, agroforests and horticultural plantations. Two scenarios are suggested in phases across 2030, 2040, and 2050. Species that can be planted is shown in Table 11 & Table 12. The land use classification of the Nilgiris district in 2022-23 is shown in Table 10.

Table 10: Land use classification of the Nilgiris district in 2022-23

Particulars		Area (in sq.km.)
Total Geographical Area		2544.85
Forests		1425.77
Not Available for Cultivation	Area Under Non-Agricultural Uses	99.87
	Barren and Unculturable Land	34.02
	Total	133.89
Other Uncultivated Land Excluding Fallow Land	Permanent Pasture and Other Grazing Land	50.78
	Land Under Misc. Tree Crops and Groves not Included in Net Area Sown	46.82
	Cultivable Waste Land	56.38
	Total	153.97
Fallow Land	Fallow Lands Other Than Current Fallows	73.25
	Current Fallow	35.31
	Total	108.56
Net Area Sown		722.66
Cropped Area		759.36
Area Sown More Than Once		36.70

Under the MES (Moderate Effort Scenario), 18 percent of the 24,245 hectares of the aforementioned land categories is proposed for development into social and agroforestry zones, resulting in a carbon sequestration potential of approximately 39 ktCO₂e/year by 2050. In the AES (Aggressive Effort Scenario), the area under social/agroforestry is expanded to cover 30 percent of the same land categories, leading to a higher projected carbon sequestration of about 64 ktCO₂e/year by 2050 (as detailed in the box item).

For developing the agro/social forestry in 2026 activities focusing on laying the groundwork – identifying suitable native species, preparing nurseries, stakeholder coordination, approvals and securing planting sites – are proposed. From 2027, plantations could be rolled out progressively across the district, integrating fallow and under-utilised land, with institutional mechanisms, irrigation facilities and building capacity. The programme could include protective measures such as fencing, maintenance systems, survival monitoring along with value chain development and impact assessment. Carbon sequestration is expected to gradually increase from 2028 as trees mature, with benefits compounding over time.

Categories of land under non-agriculture uses, barren and uncultivable land, fallow lands other than current fallow and current fallow that are suitable for agro/social forestry and horticulture interventions have been identified based on expert inputs, historic trend and literature review. In addition to this, the possible site for plantations, reforestation, and enhancing green cover have also been mapped through spatial analysis and is as represented in the map below. These areas represent high potential for enhancing carbon sequestration, restoring ecological function, and supporting sustainable land use practices.

However, it is important to note that these mapped areas are indicative in nature and serve as a preliminary planning tool. Prior to implementation, detailed on-ground verification and ecological assessments are essential to validate site suitability. Such field surveys should evaluate soil characteristics, existing vegetation, slope stability, land tenure, and proximity to water sources, among other factors, thereby ensuring that plantation activities are context-sensitive, ecologically appropriate, and aligned with long-term sustainability goals.

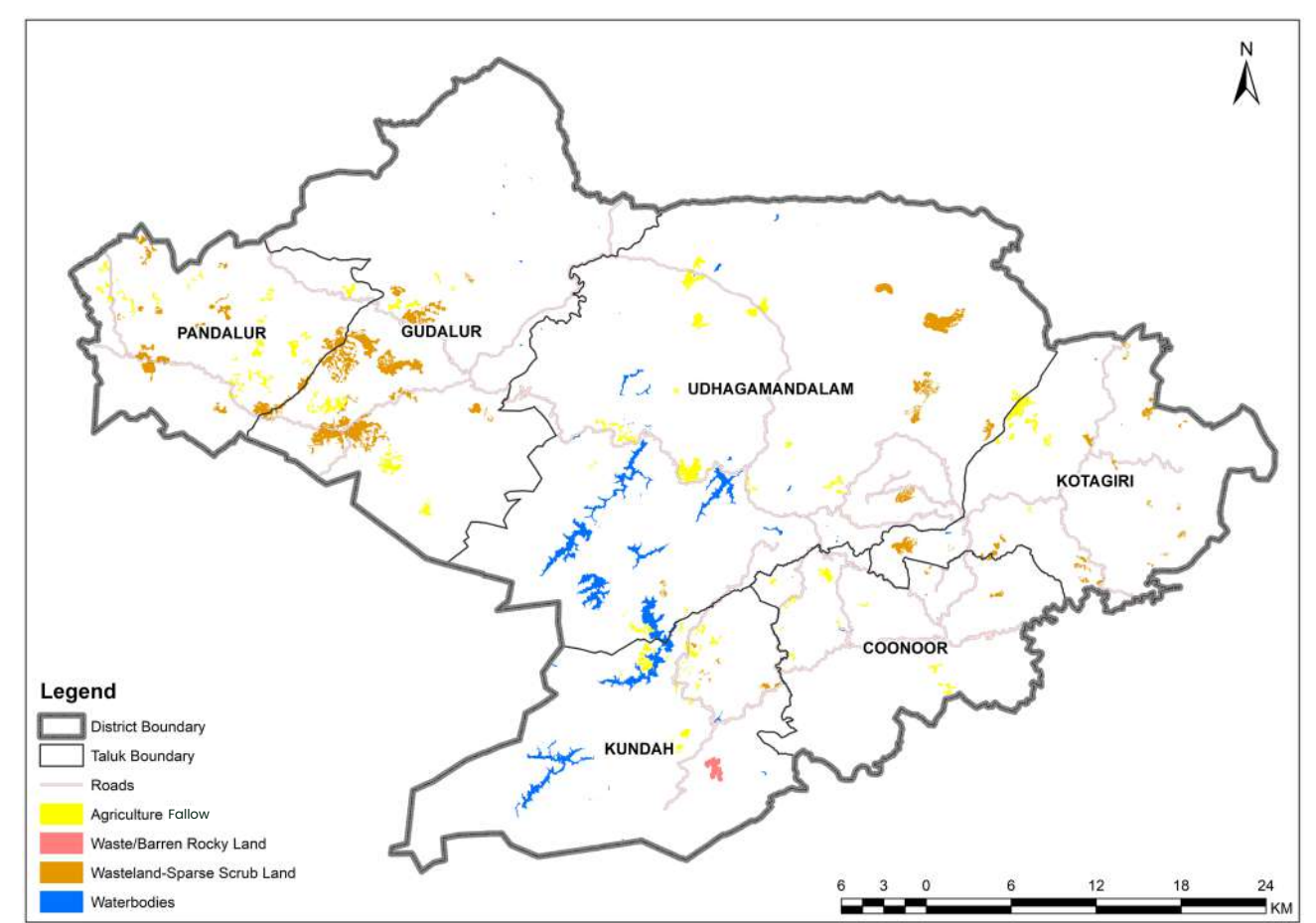


Figure 48: Fallow and wasteland areas suitable for agro/social forestry interventions

Enhancing Carbon Stock Density

In 2015, Nilgiris forests recorded a carbon stock density of 102.26 tons per hectare (t/ha), which declined to 96.22 t/ha by 2019.⁵⁸ To restore carbon stocks to near-2015 levels by 2050. MES scenario, aims for a 4% increase in density to 99.84 t/ha, while the AES scenario aims for a 6% increase, reaching 101.66 t/ha. Achieving these targets could result in carbon sequestration of approximately 69 ktCO₂e under MES and 104 ktCO₂e under AES per year respectively by 2050.

To enable this recovery and long-term enhancement of forest carbon stocks, the plan envisions a phased strategy focused on improving forest health and density through community forestry, assisted natural regeneration, and sustainable management practices. These efforts are expected to gradually boost the carbon-holding capacity of forest areas.

In 2026, the focus would be on conducting a comprehensive forest health assessment across the district to identify degraded patches, assess threats from invasive species and encroachments, and design targeted interventions suited to local ecological conditions. From 2027 onwards, the plan proposes active regeneration through community forestry initiatives, natural regeneration, and assisted planting in degraded areas. This would be accompanied by actions such as controlling invasive species, fostering native biodiversity, and engaging local communities in long-term forest stewardship.

Over the subsequent two decades, emphasis would shift to sustained maintenance and monitoring using modern tools such as satellite imagery and remote sensing. This phase would also integrate sustainable forest management practices into local governance systems—including forest fire control, prevention of illegal logging, boundary demarcation, and responsible harvesting of forest produce.

Restoration of Shola Grassland

Restoration of Shola grasslands in the 56.37 sq km of cultivable wasteland (2022–23)—offers significant sequestration potential. By 2050, these efforts could sequester up to 7 ktCO₂e under the Aggressive scenario and 5 ktCO₂e under the Moderate scenario.

In 2026, a comprehensive ecological zonation is proposed to map native grasslands, invasive-dominated patches, and forest fringes, supported by soil-moisture assessments and historical vegetation data. Early engagement with tribal communities and local stakeholders will guide inclusive planning and leverage traditional knowledge.

From 2027, restoration could proceed using mosaic planting with native grasses, herbs, legumes, and shrubs. Soil microbial recovery and moisture retention measures like trenches and swales would support long-term ecosystem health. Where possible, community nurseries, fodder cultivation, and restoration-linked employment can be integrated to enhance local ownership.

Carbon sequestration is expected to begin by 2028 and steadily increase through 2050.

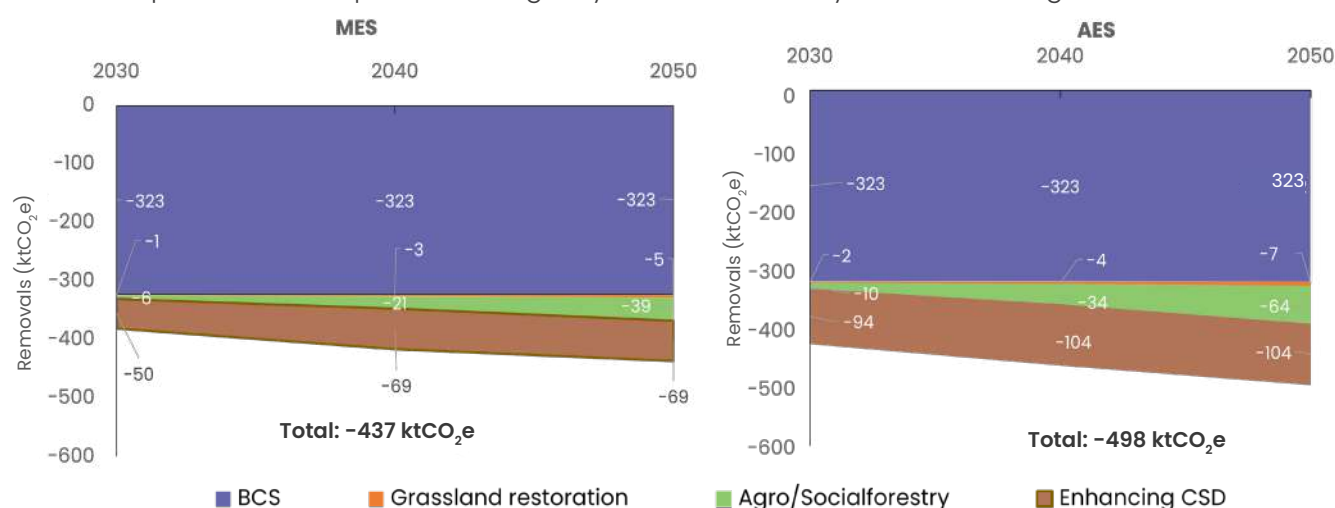


Figure 49 (a),(b): Carbon sequestration potential under alternate scenarios

The carbon stock density of the forest could be enhanced through:

- Reforestation and Afforestation: Planting trees in deforested or degraded forest patches by selecting native species adapted to the local climate and ecosystem, controlling invasive species and ensuring regular maintenance and monitoring
- Improved Forest Management: Implementing sustainable forest management practices such as minimising forest degradation through selective logging, protecting old-growth forests, and promoting natural regeneration; preventing forest degradation activities such as illegal logging and forest fires, promote sustainable collection of forest produce
- Monitor and remove encroachment of forest land.
- Use of satellite imagery and other modern technology to identify encroachment, illegal construction and plantation health, threat from invasive tree species etc,
- Demark and place appropriate boundaries for the forest lands.
- Install strategic check-points
- Promote and sponsor awareness, plantation and logging activities in the forest areas that are more susceptible to waste littering and dumping.

Additionally, forest fire management should be carried out through:

- Strategic controlled burning, where patches of the grassland is burnt at regular intervals in high forest fire susceptible zones to avoid spreading of fire across a big area, would reduce the burn extent.
- Install strategic watch stations to monitor wildfires.
- Formalise protocol for fire control and ensure immediate access to fire extinguishing equipment.
- Establish protocol for use of helicopters for dousing bigger fires across forests and sholas.
- Ground mapping and integration of Remote Sensing technology to identify fire prone areas in forest.

Benefits of agroforestry⁵⁹

- Effective alternate source of income for the farmers.
- Increase and stabilise agricultural yields and reduce soil erosion.
- Agroforestry biomass can provide fuelwood, foods, fodder, basic construction materials, shade, medicines, etc.
- It may allow land to be taken out of fallow rotation in shifting cultivation systems
- Agroforestry in urban areas can provide local biomass and help the public to recognise the usefulness of tree planting.
- Results in soil restoration through recovery of organic based nutrient cycling through restoration of soil organic matters. Trees uptake the nutrients from below the reach of the crop roots.

Table 11: Species list for plantation

Sl No	Species
1	<i>Artocarpus hirsutus</i>
2	<i>Elaeocarpus tectorius</i> (Lour.) Poir
3	<i>Ficus racemosa</i>
4	<i>Phyllanthus emblica</i>
5	<i>Rhododendron nilagiricum</i>
6	<i>Syzygium cumini</i>
7	<i>Ziziphus mauritiana</i>

Additionally, urban forestry⁶⁰ could be implemented in barren patches of the urban pockets of the district. In addition to the carbon sequestration and oxygen production, urban forests control air pollution, increase rainwater percolation, reduce urban temperatures, counter urban heat island⁶¹ effect, support urban wildlife, enhance the livability, promote tourism and lead to an increase in the property value. Linear strip plantation can be carried out in public areas especially on the sides of public roads, canals etc. Table 12 lists a few endemic species suitable for urban forestry.

Table 12: Species list for planting in public areas

SI No	Species	SI No	Species
1	<i>Albizia lebbbeck (L.) Benth.</i>	7	<i>Melia dubia</i>
2	<i>Artocarpus heterophyllus</i>	8	<i>Tectona grandis</i>
3	<i>Bauhinia purpurea L</i>	9	<i>Alstonia scholaris (L.) R.Br</i>
4	<i>Butea monosperma</i>	10	<i>Bauhinia variegata L</i>
5	<i>Cassia fistula L</i>	11	<i>Swietenia mahagoni</i>
6	<i>Ficus benghalensis</i>	12	<i>Syzygium aromaticum</i>

Other best practices for forest management

- Wetlands within and outside forests must be protected for their huge potential in acting as a carbon sink.
- Remove dumping sites along the roads in forest areas.
- Mark traversing hours for the roads that overlap with ecological sensitive zones.
- Formalise eco-tourism activity by issuing permits for trekkers and develop water, solid waste and wastewater managed camping grounds.

Restoration of Shola Forests and Grasslands in the Nilgiris District

The native vegetation of the Nilgiris is a mosaic of Native grasslands and Shola forests. As a broad generalisation it can be said that the shola forests are found in the valleys and the grasslands on the crests and outer slopes of the hills.

Over the decades, the ecology of the area has been affected by urbanisation, and conversion of forest and grasslands to plantations. Thus, it is important to restore this ecology to safeguard the local biodiversity of the endemic Nilgiris Biosphere Reserve and to improve the overall ecological and climate security.

Additionally, restoring the native ecosystems is necessary to maintain the health of the hydrological cycle and local biodiversity. The current efforts of the government revolve around restoration of the local ecology that has been affected over the decades due to plantation of non-native species like wattle, eucalyptus and conifers. Ecological restoration of the Nilgiris to maximise carbon uptake and storage could be strategised as follows:

Restoration of Shola Forests

Shola forests are patches of stunted tropical montane forest found in valleys amid rolling grassland. The patches of shola forest are found mainly in the valleys and are usually separated from one another by undulating montane grassland, where there is least reach of the fog and mist. The shola and grassland together form the shola-grassland complex or mosaic.

The existing Shola forests in the Nilgiris District could be broadly classified to one of the following five categories based on their current condition:

- Protected Shola forest that has a high degree of resemblance to the reference ecosystem model.
- Shola forest patches are degraded to some extent, with the presence of non-native species, degrading the ecological integrity of forest.
- Shola forests that are highly degraded, where few endemic key species exist, but a high percentage of non-native species, such as *Cestrum aurantiacum*, dominate the components of the forest.
- Plantation areas which are showing clear signs of Shola species regenerating in the lower canopy (indicating the proximity of a nearby shola forest from which the seeds are dispersed and getting established).
- Plantation areas where there are minimal or no signs of regeneration of Shola species.

Different restoration strategies can be adopted for each of the above categories, to ensure efficient use of resources and highest probability of success.

The following measures are suggested for categories 1, 2 and 3, where Shola Forest patches are existing:

- Protection of the area through physical and or social fencing.
- Stagewise removal of non-native species, ensuring that any native species regeneration is not disturbed. Careful monitoring to ensure that the restoration to work does not lead to further colonisation by non-native invasive species.
- In areas where there is paucity of native shola species, enrichment plantation with primary and secondary native successional species that are able to establish in the open.

For category 4, in the plantation areas where there are clear signs of regeneration, a long-term management plan (minimum 25 years) can be instigated to ensure the gradual transition from non-native plantation to native shola forest. In most cases removal of the non-natives is not necessary, but might involve appropriate ring barking⁶² of the non-natives to allow the emerging shola layer to receive more light and increase their growth rates. Additionally, some enrichment plantations of desirable shola species not represented in the lower layer might be desirable.

Category 5 could be restored through the introduction of shola species in the understory⁶³ through enrichment plantations.

Further, for all the categories, control grazing of domestic animals, and protection from the native herbivores is required in the more degraded areas, where some enrichment plantations are undertaken.

Overall, restoration of Shola forests could be carried out by firstly assessment of the existing forest areas (both native shola and plantation areas) to classify them according to their regeneration potential to one of the 5 aforesaid categories, thereby indicating the priority action. Secondly, by establishing trial patches in each of the areas monitoring so that adaptive management plans can be developed and refined for long-term restoration planning.

The species suitable for restoring shola forests are as follows:

No	Species
1	<i>Michelia nilagirica</i>
2	<i>Berberis tinctoria</i>
3	<i>Mahonia leschenaultii</i>
4	<i>Casaria thwaitseii</i>
5	<i>Casaria zeylancia</i>
6	<i>Hydnocarpus pentandra</i>
7	<i>Pittosporum tetraspermum</i>
8	<i>Pittosporum nilghirens</i>
9	<i>Polygala arialata</i>
10	<i>Ternstroemia japonica</i>
11	<i>Eurya nitida</i>
12	<i>Gordonia obtusa</i>
13	<i>Elaeocarpus glandulosus</i>
14	<i>Elaeocarpus munronii</i>
15	<i>Elaeocarpus recurvatus</i>
16	<i>Euodia luna-ankenda</i>
17	<i>Toddalia asiatica</i>
18	<i>Heynea trijuga</i>
19	<i>Nothapodytes nimmoniana</i>
20	<i>Ilex denticulate</i>
21	<i>Ilex wightiana</i>
22	<i>Cassine paniculata</i>
23	<i>Euonymus crenulatus</i>
24	<i>Microtropis ramiflora</i>
25	<i>Microtropis microcarpa</i>
26	<i>Rhamnus wightii</i>
27	<i>Sageretia hamosa</i>
28	<i>Turpinia nepalensis</i>
No	Species
29	<i>Dodonea viscosa</i>
30	<i>Meliosma pinnata</i>
31	<i>Meliosma simplicifolia</i>
32	<i>Derris brevipes</i>
33	<i>Sophora glauca</i>
34	<i>Rosa leschenaultiana</i>
35	<i>Photonia lindleyana</i>
36	<i>Photonia integrifolia</i>
37	<i>Toona cilata</i>
38	<i>Gomphandra coriacea</i>
39	<i>Rhodomyrtus tomentosa</i>

40	<i>Syzygium calaphyllifolium</i>
41	<i>Syzygium densiflora</i>
42	<i>Syzygium cumini</i>
43	<i>Syzygium tamilnadensis</i>
44	<i>Memecylon flavescens</i>
45	<i>Memecylon randerianum</i>
46	<i>Pentapanax leschenaultii</i>
47	<i>Schefflera capitata</i>
48	<i>Schefflera racemosa</i>
49	<i>Schefflera rostrata</i>
50	<i>Schefflera micrantha</i>
51	<i>Lonicera ligustrina</i>
52	<i>Viburnum cylindricum</i>
53	<i>Viburnum hebantham</i>
54	<i>Viburnum erubescens (Nilgiris, Palnis)</i>
55	<i>Ixora notoniana</i>
56	<i>Paveta breviflora</i>
No	Species
57	<i>Psychotria congesta</i>
58	<i>Lisianthes venulosus</i>
59	<i>Vernonia arborea</i>
60	<i>Helichrysum buddleoides</i>
61	<i>Vaccinium leschenaultii</i>
62	<i>Gaultheria fragrantissima</i>
63	<i>Rhododendron arboretum var. nilagiri-cum</i>
64	<i>Maesa indica</i>
65	<i>Myrsine wightiana</i>
66	<i>Xantolis tomentosum</i>
67	<i>Isonandra perrottetiana</i>
68	<i>Simplocos cochinchinensis</i>
69	<i>Prunus ceylancia</i>
70	<i>Pygeum sisparens</i>
71	<i>Symplocos foliosa</i>
72	<i>Symplocos microphylla</i>
73	<i>Symplocos pendula</i>
74	<i>Ligustrum perrottetii</i>
75	<i>Strobilanthes cuspidates</i>
76	<i>Strobilanthes gracilis</i>
77	<i>Strobilanthes papillosus</i>
78	<i>Piper argyrophyllum</i>

No	Species
79	<i>Peperomia wightii</i>
80	<i>Actinodaphne bourneae</i>
81	<i>Beilshmedia wightii</i>
82	<i>Cinnamomum perottetii</i>
83	<i>Cinnamomum wightii</i>
84	<i>Litsea quinqueflora</i> (Southern W. Ghats)
85	<i>Litsea floribunda</i>
86	<i>Litsea wightiana</i>
87	<i>Neolitsea fischeri</i>

88	<i>Neolistsea foliosa</i>
89	<i>Neolistsea zeylancia</i>
90	<i>Phoebe wightii</i>
91	<i>Elaeagnus kologa</i>
92	<i>Bischofia javanica</i>
93	<i>Glochidion velutinum</i>
94	<i>Glochidion neigherense</i>
95	<i>Glochidion fagifolium</i>
96	<i>Sarcococca trinervia</i>
97	<i>Daphniphyllum neilgherense</i>
98	<i>Celtis tetrandra</i>

The initial phase of reviving a native grassland involves setting up the foundational layer of native grass species. Due to long term land use change the soil will act as a repository for invasive exotic plant's seeds. Consequently, native grass varieties resilient enough to thrive amidst these invasive pressures must be selected.

To ensure that the grasses attain proper growth and are not wiped out by overgrazing or diseases, nurseries can be established, where saplings are nurtured for 3 months and then transplanted as per requirement.

Once the foundational layer of native grasses is established, additional native shrubs and herbs typical of grasslands can be gradually introduced.

Participation of the community, who are primary users of natural resources and possess traditional knowledge associated with their sustainable use, is critical to the restoration efforts. An eco-development committee can be formed, who can be trained and employed to carry out the restoration, thereby generating livelihood opportunities.

List of the native grass species suitable for restoration of shola grasslands

No	Species
1	<i>Andropogon lividus</i>
2	<i>Arundinella pupurea</i>
3	<i>Bothricholoea fouslskii</i>
4	<i>Chrysopogon zeylanicus</i>
5	<i>Cyrtococon decanense</i>
6	<i>Dicanthium polypticus</i>
7	<i>Dichanthium oliganthum</i>
8	<i>Eragrostis ambalis</i>
9	<i>Eriochrysis rangacharii</i>
10	<i>Erioculon robusta</i>
11	<i>Themeda triandra</i>

No	Species
12	<i>Eulalia phaeothrix</i>
13	<i>Eulalia wightii</i>
14	<i>Helichtotrychon virisence</i>
15	<i>Heteropogon contortus</i>
16	<i>Ischaemum indicum</i>
17	<i>Juncus effucius</i>
18	<i>Panicum paspallum</i>
19	<i>Tripogon bromoides</i>
20	<i>Tripogon jaquemontii</i>
21	<i>Zenkeria elegans</i>

This chapter analyses GHG emissions projections from 2022 to 2050 across the three scenarios: BCS, MES, and AES. The energy sector emerges as the primary contributor to emissions growth, with transport driving 39% percent of the increase. AFOLU plays a crucial role in offsetting emissions, with sequestration improving significantly in MES and AES.

As a mountainous district with steep slopes and fragile soils, the Nilgiris is increasingly vulnerable to landslides and extreme rainfall events intensified by climate change. Integrating disaster risk mitigation—particularly slope stabilization and ecosystem restoration—into agroforestry and reforestation efforts is essential for enhancing carbon sequestration, improving carbon stock density, and ensuring the resilience of these climate mitigation interventions. Such integration not only prevents soil erosion and land degradation but also protects long-term carbon storage potential, safeguards community livelihoods, and reduces the risk of climate-related disruptions to restoration outcomes.



Disaster Risk Mitigation for Nilgiris District: Addressing Climate-Induced Rainfall Extremes and Landslide Vulnerability

The Nilgiris, perched at the intersection of the Western and Eastern Ghats in Tamil Nadu, is among the most ecologically sensitive and hazard prone districts in India. The district’s unique topography, steep slopes, fragile soils, and dense human settlements, makes it particularly vulnerable to hydro-meteorological disasters, especially flash floods and landslides. With climate models projecting sharp increases in both rainfall intensity and frequency by 2090 (detailed in Chapter 3), the need for a robust, locally grounded and forward-looking disaster risk mitigation strategy has never been more urgent. This framework integrates the projected climate trends with historical disaster data and local governance mechanisms from the **Nilgiris District Disaster Management Plan (2024)** to present an actionable roadmap for resilience.



Southwest Monsoon

- Rainfall increase from 697 mm to 1133 mm (~63% increase)
- Rainy days increase from 43 to 60 (~40% increase)



Winter Monsoon

- Precipitation increase from 384 mm to 460 mm (~20% increase)
- Rainy days increase from 24 to 30 (~25% increase)

These changes imply heightened risks of landslides, flash floods, and soil erosion, especially in the hilly terrains of the Nilgiris district. Some of the identified high-Risk and Landslide-Prone Areas are as follows:

Coonoor Taluk: Selas, Krishnapuram, Marapalam, Hillgrove, Pudukadu

Kotagiri Taluk: Kodanad, Ketti, Doddacombai

Udhagamandalam: Manthada, Kookalthorai, Ketti Valley

Kundah Taluk: Balacola, Avalanche, Emerald

Gudalur & Pandalur: Flash flood and debris flow zones, especially Nelliyalam, Devala, O’Valley

Strengthened Disaster Risk Mitigation Measures

Land Use Planning & Slope Stabilization

- Develop Hazard Zonation Maps based on geological strength index for slope development control.
- Restrict new development in high landslide risk zones such as Selas and Krishnapuram.
- Adopt bioengineering and geo-engineering methods:
 - » Vetiver and bamboo plantations for vegetative stabilization.
 - » Gabion walls, retaining structures, and rock bolting.
 - » Introduce geo-fibers and geotextiles on slopes in Ketti Valley, Marapalam, and Kundah Ghat roads to prevent surface run-off erosion and deep-seated slips.

Urban and Rural Water Management

- Desilting and channel widening in Ooty's Kodappamund Stream (multiple segments).
- Check dams in Kundah, Avalanche, Masinagudi sub-basins.
- Restore traditional tanks and channel systems in Cherangode and Padanthorai.

Forest and Ecosystem Restoration

- Reforest Mukurthi-Avalanche, Glenmorgan, and Denad slopes with native Shola grasslands.
- Engage Toda, Kurumba, and Badaga communities in afforestation via Joint Forest Management.

Infrastructure Resilience

- Retrofitting of roads and culverts on NH-181, especially Burliar-Coonoor and Kotagiri-Mettupalayam.
- Install real-time landslide and rainfall sensors on critical road and rail corridors.
- Climate-resilient design for Primary Health Care Centers (PHCs), schools and other infrastructure.

Early Warning and Emergency Systems

- Expand automatic weather station/ automatic rain gauge (AWS/ARG) network at locations including Masinagudi, Yedapalli, Nanjanad, Cherumulli, Kokkal.
- Community alert systems linked to District Emergency Operations Centre (DEOC) in Udthagamandalam.



6. Aggregate Scenario Results and Key Insights

This chapter analyses GHG emissions projections from 2022 to 2050 across the three scenarios: BCS, MES, and AES. The energy sector emerges as the primary contributor to emissions growth, with transport driving 39% percent of the increase. AFOLU plays a crucial role in offsetting emissions, with sequestration improving significantly in MES and AES.

6.1 Gross and Net GHG Emissions

The aggregate gross GHG emissions in the BCS scenario are expected to rise from 334 ktCO₂e to 448 ktCO₂e from 2022 to 2050. Thus, noting a 34% growth during this period. About 70% of the growth in emissions is contributed by the energy sector, while the waste, industrial processes and other sectors contribute marginally to the overall emissions increase by 2050. As discussed earlier in Chapter 5, the transport sector contributes significantly to the rise in sectoral energy-related emissions, accounting for 57% of the total energy emissions in 2050.

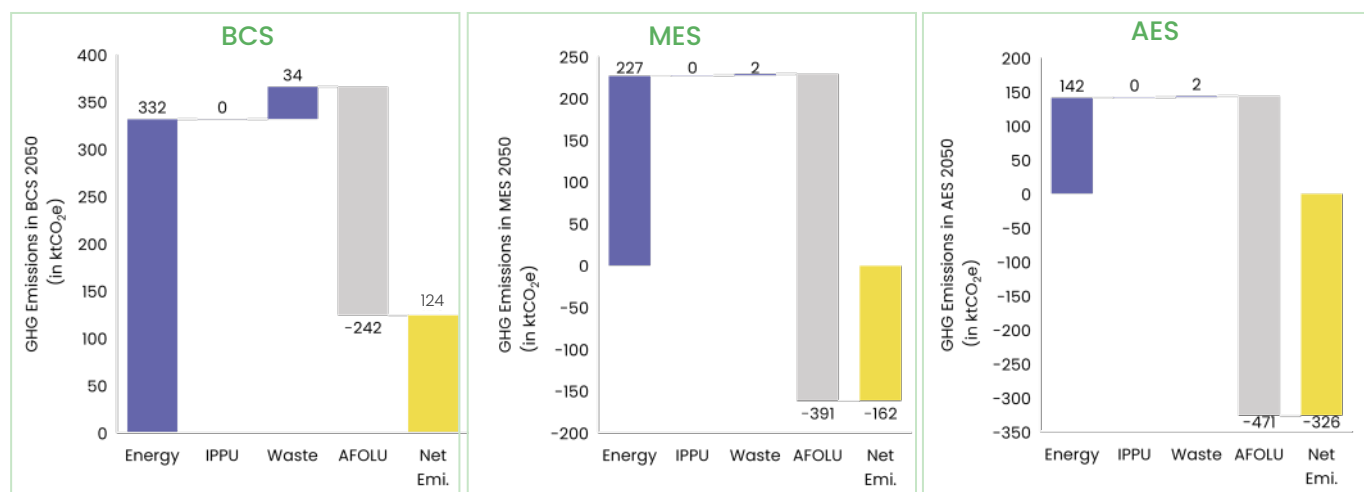


Figure 50: Emissions mitigation under various scenarios in 2050

The Figure 50 presents emissions across three scenarios: BCS, MES and AES. In the BCS 2050, energy contributes the highest emissions at 391 ktCO₂e, while waste contributes 34 ktCO₂e, and AFOLU (Agriculture, Forestry, and Other Land Use) offsets 242 ktCO₂e, resulting in net emissions of 124 ktCO₂e. Under the MES, energy emissions decrease significantly to 227 ktCO₂e, waste emissions drop sharply to 2 ktCO₂e, and AFOLU sequestration increases to 388 ktCO₂e, leading to net negative emissions of -162 ktCO₂e. In the AES scenario, even more aggressive decarbonisation measures across transport and residential fuel switching reduces energy emissions further to 142 ktCO₂e, and AFOLU sequestration grows to 471 ktCO₂e, driving net emissions to -326 ktCO₂e.

6.2 Pathways to Decarbonise the Nilgiris and Key Insights

Figure 51 shows the emissions reduction trajectory in the Nilgiris district. The dashed line shows net emissions, while the solid line represents gross emissions across all the scenarios. Gross emissions are projected to rise from 334 to 448 ktCO₂e between 2022 and 2050, while emissions drop to 275 in the MES and 172 ktCO₂e in the AES by 2050. Among the decarbonisation measures, electrification of road transport energy efficiency and Fuel switching is expected to contribute significantly to the drop in energy emissions by 2050. Waste management and other land use practices provide a marginal drop in GHG emissions, whereas, land-based sequestration would contribute highest drop in GHG emissions.

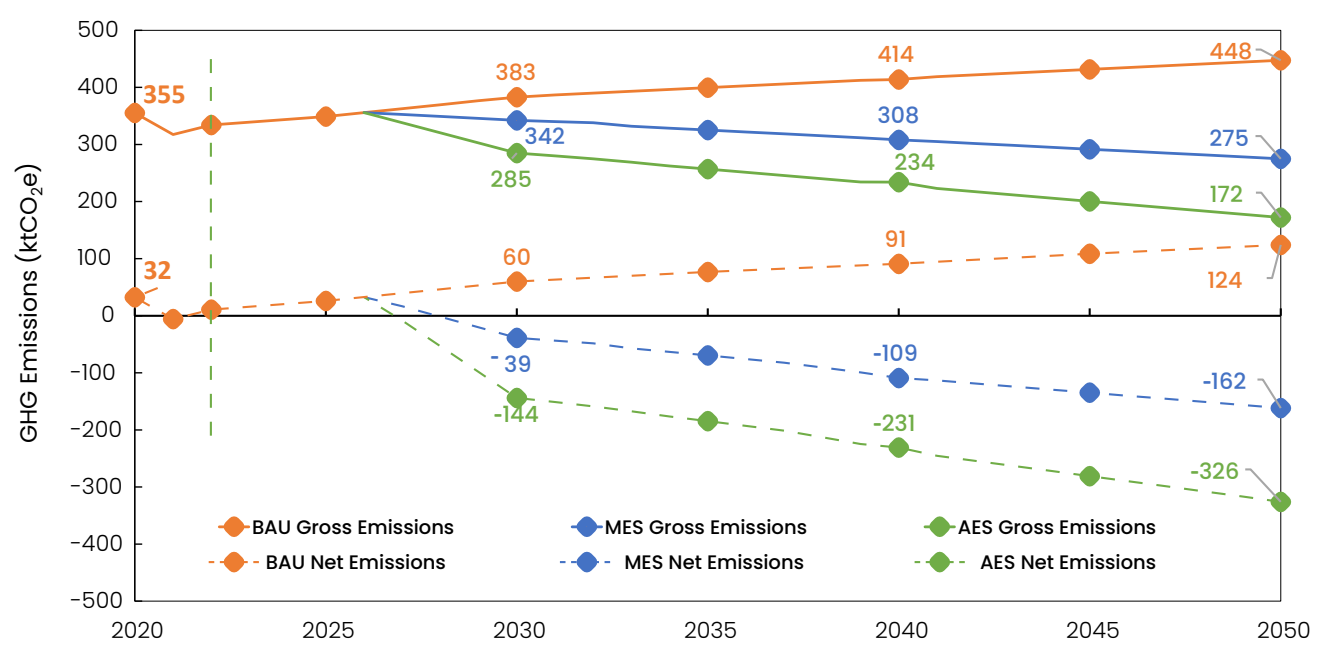


Figure 51: Emissions reduction trajectory under BAU, MES and AES between 2022 and 2050

The emissions projected at 448 ktCO₂e under BAU in 2050 could be mitigated through waste management (32 ktCO₂e, 7%), aggregate & non-CO₂ (54 ktCO₂e, 12%), EVs (86 ktCO₂e, 19%), fuel switching (66 ktCO₂e, 15%), and industrial decarbonization (38 ktCO₂e, 8%). Further, BAU sequestration along with enhanced carbon stock density and agroforestry could offset 498 ktCO₂e (111%). Together, these interventions achieve a mitigation potential of 172%, reducing net emissions to -326 ktCO₂e by 2050, with net zero projected to be reached as early as 2028.

6.3 Key Insights Emerging from the Decarbonisation Pathways

The district can achieve carbon neutrality well before 2030 through concentrated efforts towards increasing land-based sequestration and some energy sector decarbonisation measures.

Under the BCS scenario, GHG emissions could increase from 334 ktCO₂e in 2022 to 448 ktCO₂e by 2050. Whereas, the analysis in this study suggests that GHG emissions could reach net zero by 2028 itself. This will require concerted efforts towards both mitigation and adaptation measures at the district level. This would require robust Stakeholder collaboration resulting in faster implementation of interventions including higher sequestration, penetration of electric vehicles, clean cooking, waste utilisation etc.

Transforming the Nilgiris into a sustainable tourism hotspot

The district witnesses ~3 million tourists annually. There is a need to support infrastructure for the rising influx of tourists by developing green-certified hotels and tourist sites. Ooty, being the first city in the country to declare a plastic ban, can further improve waste management practices, including wastewater treatment, composting organic waste from hotels and restaurants, resulting in 36 ktCO₂e GHG emission abatement.

Further, sustainable mobility including electric tourist buses, and pedestrian-only zones in high-footfall areas could be developed in the district.

Huge role of sequestration would mean enhancing forest management practises

About 498 ktCO₂e GHG emissions could be sequestered in the district through various measures. This would require forest management practises, restoring grasslands, expanding agroforestry, and increasing carbon stock density. Scaling up agroforestry practices to integrate carbon sequestration with livelihood benefits would be crucial. Establishing a district-wide monitoring framework to track sequestration impact could enhance compliance.

Electricity sector growth would mean strengthening the infrastructure in the district

Despite the district being carbon neutral from electricity standpoint, the consumption is expected to rise from 425 GWh to 711-865 GWh across the scenarios by 2050. Clean and green generation from hydro plants in the region is anticipated to generate ~2100 GWh, comparatively higher than the consumption in the district. Rapid electrification across sectors would further require strengthening the distribution infrastructure to make grid future ready.

Converging central policies in district could enhance GHG mitigation across end use sectors

The district has significant potential to increase rooftop solar potential in the district. With upfront subsidy through PM-Surya Ghar Muft Bijli Yojana, the district can expedite decentralised electricity generation. Thus, thorough assessment of rooftop potential is needed. Further, PM-KUSUM scheme could be utilised to replace diesel pumps with solar pumps, thus abating ~11 ktCO₂e GHG emissions.

Institutionalising behavioural change & capacity building

Measures to enhance public transport, Switch to e-cooking, adopting energy efficient appliances, efficient built spaces are expected to contribute ~200 ktCO₂e to emissions abatement. It would thus need capacity building and awareness towards adoption of clean technologies and practises across communities. Implementing financial incentives and policy nudges (e.g. subsidies for public transport use) would expedite the interventions in the district.



Sustainable Ecotourism Guidelines for Nilgiris District

Background

The Nilgiris, a critical part of the Western Ghats and a UNESCO Biosphere Reserve, is home to unique biodiversity and a vibrant cultural landscape inhabited by indigenous tribal communities. Ecotourism, when responsibly planned and implemented, offers a path to sustainable development, community empowerment, and conservation finance. This document proposes a comprehensive framework aligned with the National Strategy for Ecotourism (2022) to guide ecotourism development in the Nilgiris.

Outcomes

- Ecotourism contributes to conservation and creates sustainable livelihood opportunities.
- Tribal communities actively participate in and benefit from ecotourism initiatives.
- Ecological and cultural assets of the Nilgiris are protected through responsible tourism.
- Government revenue and visitor experience improve through effective regulation and innovation.

Key Policy Recommendations

Ecotourism Zonation & Planning

- Identify and map ecologically sensitive and culturally significant areas using GIS-based tools.
- Classify zones:
 - » Core (restricted) – critical habitats like Mukurthi NP
 - » Buffer (controlled tourism) – Mudumalai, Avalanche
 - » Cultural/Community (interactive tourism) – tribal hamlets, historic-era villages
- Plan eco-circuits that balance biodiversity conservation with cultural tourism (e.g., Ooty–Avalanche–Toda village circuit).

Tribal Upliftment and Inclusion

- Recognize tribal communities (Toda, Kota, Irula, Kurumba, Paniya etc.) as primary custodians and beneficiaries of ecotourism.
- Ensure joint ownership of tourism enterprises under cooperative or trust-based models.
- Facilitate access to:
 - » Capacity-building (hospitality, storytelling, craft marketing)
 - » Micro-finance or revolving fund schemes
 - » Digital platforms to market tribal homestays, eco-guides, and crafts
- Provide land use security for tribal ecotourism ventures via Forest Rights Act provisions.

Heritage Villages and Cultural Corridors

- Designate and develop “Eco-Heritage Villages” in areas with strong tribal or historic legacies (e.g., Tranquebar-style settlements or Toda munds).
- Restore traditional architecture and cultural landscapes with support from heritage architects.
- Introduce living museums, tribal art installations, and ethnobotanical gardens that reflect indigenous knowledge.
- Integrate storytelling-based tourism involving elders and tribal youth.

Participatory & Volunteering Tourism

- Promote “Voluntourism” models where visitors contribute time or skills to conservation, education, and tribal empowerment. Examples: forest restoration, traditional farming, teaching in tribal schools, craft-making
- Create a district-level voluntourism platform in collaboration with local NGOs, colleges, and civil society.
- Offer certified eco-volunteer experiences with tangible benefits for participants and host communities.

Revenue Generation for Government Stakeholders

- Use a multi-tiered revenue system:
 - » Entry fees, eco-guide charges, vehicle permits
 - » Revenue-sharing agreements with homestays and ecotourism operators
 - » Annual licensing and green certification fees
- Allow the Forest Department and Panchayats to retain a portion of local earnings for reinvestment in conservation and community programs.
- Implement e-ticketing systems to reduce leakage and improve transparency.

Visitor Management and Carrying Capacity

- Introduce a mandatory online booking system to:
 - » Control visitor numbers based on zone-specific carrying capacities
 - » Enable dynamic pricing to regulate high-season rush
 - » Register tourists for impact tracking and insurance
- Use GIS and drone data to update carrying capacity estimates annually.
- Provide visitor caps, zoning rules, and real-time updates at entry points and websites.

Sustainable Infrastructure and Waste Management

- Mandate vernacular architecture and sustainable materials for all ecotourism structures (e.g., Toda-style roofs, wood and mud construction).
- Implement off-grid energy, compost toilets, rainwater harvesting, and plastic-free zones in all ecotourism sites.
- Provide design and financial support for tribal homestay upgradation.
- Mandate eco-friendly construction and renewable energy for all facilities
- Establish community-managed solid waste hubs and plastic-free zones
- Promote compost toilets, rainwater harvesting, and greywater recycling

Governance and Monitoring

- Constitute a Nilgiris Ecotourism and Heritage Council (NEHC) comprising: Forest Dept, Tribal Welfare Dept, NGOs, Panchayat reps, tribal elders, ecotourism operators.
- Define community rights, revenue-sharing models, and accountability mechanisms through local bylaws. Use participatory monitoring and citizen science tools
- Publish annual Ecotourism Impact Reports

Branding, Education, and Outreach

- Establish a Tribal Ecotourism Academy in Nilgiris for:
 - Multilingual training in guiding, sustainable hospitality, and entrepreneurship
 - Certification of eco-guides and cultural interpreters

- Launch a “Voices of the Nilgiris” storytelling platform to amplify tribal knowledge and ecological wisdom.
- Develop and market the “EcoNilgiris” brand with curated experiences (e.g., “Live with the Todas”, “Volunteer in the Sholas”)

Funding avenues:

- Swadesh Darshan 2.0, Dekho Apna Desh, Tribal Tourism Development Plans
- Tamil Nadu Ecotourism, Rural Tourism, and Green Skill Development Schemes
- Mobilize CSR funding, PPPs, and climate-resilient tourism finance through national and international donors

Implementation Roadmap: Sustainable & Inclusive Ecotourism in Nilgiris

Phase I (0–6 months): Baseline assessments, zonation, stakeholder consultations

Activity	Key Stakeholders	Deliverables
Set up Nilgiris Ecotourism & Heritage Council (NEHC)	District Collector, Forest Dept, Tribal Welfare Board	Institutional framework with TOR
Conduct baseline mapping: Ecological zones, tribal settlements, tourism hotspots	Forest Dept, Tourism Dept, NGOs	Zonation and resource map
Define carrying capacities per zone using ecological indicators	Ecologists, NGOs, academic institutions	Visitor caps, sensitivity index
Draft and notify district-level eco-tourism policy guidelines	NEHC, Legal Cell	Draft guidelines gazetted
Identify 2–3 pilot sites for ecotourism development	NEHC, Panchayats	Selected pilot locations

Phase II (6–18 months): Infrastructure roll-out, training, and digital platform development

Activity	Key Stakeholders	Deliverables
Launch Eco-Guide and Homestay Training Programs	Forest Dept, Tourism Dept, skill development agencies	100+ trained guides and hosts
Upgrade/establish Eco-Heritage Villages (Toda, Kota, Kurumba areas)	Panchayats, INTACH, Tribal Affairs	Functional heritage sites with visitor facilities
Build/retrofit eco-lodges, nature interpretation centres, and waste hubs	TN Tourism Infra Corp, PWD, NGOs	3+ eco-infrastructure units completed
Develop voluntourism packages and portal	NGOs, Academic partners	Live portal and first batch of volunteers
Start e-permit and visitor registration system	Forest Dept, IT agency	Booking platform with caps per zone

Phase III (18–36 months): Expansion, evaluation, branding, and policy refinement

Activity	Key Stakeholders	Deliverables
Launch official operations in pilot zones	NEHC, Panchayats	First tourists under new system
Roll out eco-certification & licensing for all tourism operators	Tourism Dept, Pollution Control Board	Green rating framework and licenses
Implement revenue sharing mechanism and Eco-Reinvestment Fund	Forest Dept, Panchayats	Transparent fund model with annual audit
Enforce zero-waste tourism protocols in each site	Local SHGs, Panchayats	No single-use plastic zones, composting in place
Organize annual Ecotourism Festival & Cultural Exchange	Tribal Welfare, Tourism Dept	Event calendar and promotional impact

Phase 4: Monitoring, Scale-Up & Adaptation (Year 4–5 and beyond)

Activity	Key Stakeholders	Deliverables
Conduct independent impact assessments (ecological, economic, social)	External agencies, academic bodies	Ecotourism Impact Report
Scale up to additional zones based on lessons from pilots	NEHC, Forest Dept	At least 3 new zones operational
Publish annual Ecotourism Dashboard (open data portal)	IT Cell, NEHC	Real-time stats on tourism, income, ecology
Institutionalize feedback systems from tourists and tribal hosts	NGOs, tourism operators	Quarterly review reports
Integrate with state tourism master plan and pitch for national/international partnerships	State Tourism Board, CSRs, UNDP	Mainstreaming and long-term sustainability



7. Financing Decarbonisation of the Nilgiris District

7.1 Activity-wise Tentative Financial Requirement/ Plan

This chapter provides a detailed list of interventions for both the energy and non-energy sectors along with the estimated budgets and estimated GHG emission reduction potentials.

Of the total anticipated investments towards meeting district decarbonisation target, Energy sector would require ₹7,425 Crores and ₹1,802 Crores towards mitigating emissions from Waste Management, land-based carbon sequestration and sustainable agriculture. Of the total anticipated Energy Sector investments, Road transport sector contributes ~90% of the total required investment. This investment goes towards upfront purchase of light as well as heavy duty segment vehicles. Whereas, rest of the investment would be required to integrate solar pumps, rooftop solar into the grid as well as upfront purchase of energy efficient appliances and electric cooktops in the district.

The Nilgiris district requires an expenditure of ₹135 Crores for wastewater management, including the establishment of centralised treatment plants for urban areas, retrofitting the unlined soak pits to twin-pit or leach pit based septic tanks and develop Fecal Sludge Treatment Plants (FSTPs) at Gram Panchayat cluster level. To enhance the district's carbon sequestration capacity, efforts such as Shola grassland restoration, increasing carbon stock density, and promoting agroforestry efforts, that could mitigate 498 ktCO₂e, could be taken up at an expense of ₹187 Crores. Sustainable agricultural practices, such as replacing synthetic fertilisers with organic alternatives and nano urea, as well as improving livestock feed, can further reduce emissions. Implementing these practices towards sustainable agriculture would require an estimated budget of ₹1020 Crores.

Table 13: List of Interventions with estimated budget and emission reduction potential

Sr no	Key intervention	New energy matrix	Target for year 2030	Approximate annual mitigation potential in 2030 (ktCO ₂ e) (Percentage to bau gross emissions)	Target for year 2050	Approximate annual mitigation potential in 2050 (ktCO ₂ e) (Percentage to bau gross emissions)	Financial implications till 2050 (in Rs Cr)	Policies/fiscal measures by state and central govt.
Scope 1 Interventions								
A Harnessing Renewable Energy Potential								
A1	Use of solar pump in the region	Currently district has a approximately 2000 electric based pumps	1120 solar pumps (5HP) to be installed for irrigation	6 (1.61%)	880 additional solar pumps (5HP) to be installed for irrigation	11 (2.46%)	50	PM-KUSUM
B Clean and Sustainable Practices								
B1	Shift to Private Electric Mobility	Replacing ~37500 conventional 2W with EV by 2050	A total of ~7500 electric 2-wheelers to be added to the stock by 2050	4 (~1%)	An additional 30000 electric 2-wheelers to be added to the stock between 2030 and 2050	19 (4.25%)	658	PM E-Drive, Tamil Nadu EV policy, FAME, Vehicle Scrapping Policy and other fiscal measures of the state and central government
		Replacement of ~9800 ICE commercial/private 4W with EV by 2050	A total of ~3300 electric 4-wheelers to be added to the stock by 2030	4 (~1%)	An additional 8400 electric 4-wheelers to be added to the stock between 2030 and 2050	28 (6.26%)	4800	
B2	Electrify the Public and heavy transport vehicles (3 wheelers, buses and trucks)	Replacing ~200 Intra district diesel buses (for schools, public transport and commercial mini buses) with EV by 2050	A total of ~40 electric buses to be added to the stock by 2050	3 (~1%)	An additional 160 electric buses to be added to the stock between 2030 and 2050	16 (3.58%)	480	

Sr no	Key intervention	New energy matrix	Target for year 2030	Approximate annual mitigation potential in 2030 (ktCo ₂ e) (Percentage to bau gross emissions)	Target for year 2050	Approximate annual mitigation potential in 2050 (ktCo ₂ e) (Percentage to bau gross emissions)	Financial implications till 2050 (in Rs Cr)	Policies/fiscal measures by state and central govt.
		Replacing ~7400 3W ICE vehicle with EV by 2050	A total of ~1400 electric 3-wheelers to be added to the stock by 2050	2 (~1%)	An additional 6000 electric 3-wheelers to be added to the stock between 2030 and 2050	11 (2.46%)	90	
		Replacement of small ~165 fleet trucks/lorries and other small goods vehicle with EV by 2050	A total of ~40 electric HGVs to be added to the stock by 2030	3 (~1%)	An additional 125 electric HGVs to be added to the stock between 2030 and 2050	13 (2.9%)	800	
B3	Creation of EV Charging infrastructure	Installing 10 new charging station	-	-	5 charging stations on petrol pumps and 5 charging stations in the optimal positions near bus depots	N/A	4.8	
B4	Cooking Fuel switching (Bio-mass and LPG to electricity)	Residential households to shift to electric cook-stoves	0.66 lakh electric cookstoves to replace LPG in households by 2030	20 (5.20%)	1.1 lakh additional electric cookstoves (two plate) to be use in place of conventional LPG gas stoves by 2050	55 (12.29%)	28	Go-electric campaign, National Efficient Cooking Program (NECP), Mission LIFE
B5	Electrification of Industrial Processes	Replacement of wood heater with electric heaters in the tea industry	Replace 40% of the fuelwood in industry use with electricity	19 (4.93%)	Replace 80% of the fuelwood in industry use with electricity	38 (8.49%)	-	-
	Total mitigation potential by 2030			60 (15.7%)	Total mitigation potential by 2050	191 (42.68%)		

Sr no	Key intervention	New energy matrix	Target for year 2030	Approximate annual mitigation potential in 2030 (ktCo ₂ e) (Percentage to bau gross emissions)	Target for year 2050	Approximate annual mitigation potential in 2050 (ktCo ₂ e) (Percentage to bau gross emissions)	Financial implications till 2050 (in Rs Cr)	Policies/fiscal measures by state and central govt.
Scope 2 Interventions								
a	Rooftop Solar	Potential Assessment of Solar rooftop in the district and installation				To be estimated based on potential assessment	To be estimated based on potential assessment	PM-Suryaghar Muft Bijli Yojana, Grid Connected Rooftop Solar Programme
b	Energy Efficiency improvements (All Mitigation potential in this category is computed based on state's mean electricity emission intensity)	Increasing share of energy efficient water heaters in new heater sales	A total 0.6 lakhs 3/5 star water heater to be used for water heating purposes	45.3	An additional 0.15 lakhs 3/5 star water heater to be used for water heating purposes	57	4	National Mission for Enhanced Energy Efficiency (NMEEE), MTEE, FEEED, EEFP
		Increasing share of energy efficient space heaters in new heater sales	A total 0.24 lakhs 3/5 star space heater to be used for space heating purpose	11.3	A total 1700 3/5 star space heater to be used for space heating purpose	12	8	
		Increasing share of energy efficient refrigeration units in new sales	A total ~1.2 lakh 3/5 star refrigeration units are to be used for cooling purposes	14.6	An additional 0.4 lakh 3/5 star refrigeration units are to be used for cooling purposes	19	288	
		Residential households to adopt LED bulbs to replace incandescent bulbs	5.42 lakh LED bulbs to be installed in the region to replace old lighting stock	15.2	9 lakh LED bulbs to be installed in the region to replace old lighting stock	25	7	NMEEE, UJALA

Sr no	Key intervention	New energy matrix	Target for year 2030	Approximate annual mitigation potential 2030 (ktCo ₂ e) (Percentage to bau gross emissions)	Target for year 2050	Approximate annual mitigation potential 2050 (ktCo ₂ e) (Percentage to bau gross emissions)	Financial implications till 2050 (in Rs Cr)	Policies/fiscal measures by state and central govt.
		Inefficient public building and street lights to be replaced with LED lights	1.07 lakh street and public place lights to be replaced by year 2030	11.3	An additional 0.3 lakh street and public place lights to be replaced between 2030 and 2050	73	17	NMEEE, UJALA
		Adoption of Other Five-star appliances, BLDC fan	3.5 lakh fans to be replaced with energy-efficient fans	37.0	An additional 8000 fans to be replaced with energy-efficient fans between 2030 and 2050	37.9	70	Energy Efficient Fans Platform(EEFP)
	Total mitigation potential by 2030			134.73	Total mitigation potential by 2050	224		

Non-Energy Interventions

C	Waste Management in the Region							
C1	Wastewater management	Set up adequate centralised wastewater treatment plants for urban	Facility to treat 45 MLD of wastewater	33.3 (8.69%)	Repair and maintenance of STPs and UGD	32.05 (7.16%)	56.25	AMRUT 2.0, Kalaignarin Nagarpura Mempattu Thittam (KNMT), Tamil Nadu Urban Development Project (TNUDP) III, Namakku Namade Thittam
		Twin pit septic tanks	Retrofitting unsanitary septic tanks and unlined hole in the ground with leach pit or twin-pit septic tanks at household level in rural areas		Additional maintenance		16.75	

Sr no	Key intervention	New energy matrix	Target for year 2030	Approximate annual mitigation potential in 2030 (ktCO ₂ e) (Percentage to bau gross emissions)	Target for year 2050	Approximate annual mitigation potential in 2050 (ktCO ₂ e) (Percentage to bau gross emissions)	Financial implications till 2050 (in Rs Cr)	Policies/fiscal measures by state and central govt.
		Setting up Fecal Sludge treatment plant (FSTP) at village level cluster level	5 FSTPs for village panchayat clusters of 5		Additional maintenance		3.75	
		Increase household connections to underground drainage, promote pitbased treatment for remote houses	75 % Households to be connected with UGD		100 % Households to be connected with UGD		56.25	
	Total mitigation potential by 2030			33.3 (8.69%)	Total mitigation potential by 2050	32.05 (7.16%)		
D	Carbon Sequestration							
DI		Maintaining the current carbon stock densities to ensure the carbon sequestration of -323 ktCO ₂ e per year	Strengthening protection around existing reserved forest areas with additional measures of protection like: strengthening the fencing; eliminating agroahment; levying penalty on defaulters; etc.	323 (84.30%)	Strengthening protection around existing reserved forest areas with additional measures of protection like: strengthening the fencing; eliminating agroahment; levying penalty on defaulters; etc.	323 (72.22%)	25	

Sr no	Key intervention	New energy matrix	Target for year 2030	Approximate annual mitigation potential in 2030 (ktCo ₂ e) (Percentage to bau gross emissions)	Target for year 2050	Approximate annual mitigation potential in 2050 (ktCo ₂ e) (Percentage to bau gross emissions)	Financial implications till 2050 (in Rs Cr)	Policies/fiscal measures by state and central govt.
	Restoration and conservation of existing forest area and tree cover	Promoting social and agroforestry in land classified as barren or fallow, land put to non-agricultural uses of cultivable waste land	"Social and agroforestry in 1,819 ha (8% of 24,245 hectares of land which is either barren, fallow, and land used for non-agricultural purposes)"	10 (2.61%)	"Social and agroforestry in 7,276 ha (30% of 24,245 hectares of land which is either barren, fallow, and land used for non-agricultural purposes) In the subsequent years, continuous monitoring and maintenance of the plantations need to be undertaken"	64 (14.31%)	164	Sub-mission on Agroforestry (SMAF) – Har Medh Par Ped Scheme ; National Agriculture Development Programme (NADP); Green India Mission; Green Tamil Nadu Mission; Trees Outside Forests in India' initiative by MoEFCC and Government of Tamil Nadu; State Compensatory Afforestation Fund Management and Planning Authority Fund (State CAMPA fund)
		Enhancing Carbon stock density	Enhancement of carbon stock density by 2% from 96.22 t/ha to 98.03 t/ha	94 (24.39%)	Enhancement of carbon stock density by 6% from 96.22 t/ha to 101.66 t/ha	104 (23.15%)	10	
		Restoration of grassland	Restoration of grassland in the existing degraded area and additionally in 14.09 sq km land classified as cultivable wasteland	1.7 (0.44%)	Restoration of grassland in the existing degraded area and additionally in 56.37 sq km land classified as cultivable waste-land	7 (1.52%)	50	
	Total mitigation potential by 2030			428 (112%)	Total mitigation potential by 2050	498 (111%)		

Sr no	Key intervention	New energy matrix	Target for year 2030	Approximate annual mitigation potential in 2030 (ktCo ₂ e) (Percentage to bau gross emissions)	Target for year 2050	Approximate annual mitigation potential in 2050 (ktCo ₂ e) (Percentage to bau gross emissions)	Financial implications till 2050 (in Rs Cr)	Policies/fiscal measures by state and central govt.
E	Behavioural Interventions* *Behavioural interventions can be implemented immediately, but may only yield substantial results over long run."							
E1	Use of more intra-regional public transport	More penetration of intra city transport to reduce dependency on private mode of transport	Introducing 70 new intra city buses as feeder and last mile connectivity			6.44	70	Mission LIFE
E2	Enhancing Non Motorised Transport (NMT): Formation of sidewalks, pedestrian zones, and safe crosswalks for walkers and cyclists, specially women and children.	Enhancing Non Motorised Transport (NMT): Formation of sidewalks, pedestrian zones, and safe crosswalks for walkers and cyclists, specially women and children	As per masterplan			NA	50	
E3	Automation of lighting in commercial segment	Installation of lighting sensors in commercial buildings	2162 (20% of total commercial buildings) building to use lighting sensors			7.9	0.22	
E4	Efficient driving behaviour	Improvement in ICE Vehicle Efficiency by 0.5% annually	Majority ICE 2W and 4W in the LPA show efficient driving behaviour			18	NA	

Sr no	Key intervention	New energy matrix	Target for year 2030	Approximate annual mitigation potential in 2030 (ktCO ₂ e) (Percentage to bau gross emissions)	Target for year 2050	Approximate annual mitigation potential in 2050 (ktCO ₂ e) (Percentage to bau gross emissions)	Financial implications till 2050 (in Rs Cr)	Policies/fiscal measures by state and central govt.
E5	Waste	Awareness campaigns to inform the residents of the importance of waste segregation and to promote sustainable practices such as repair, reuse, recycle, reduce	Enhanced awareness of residents and commercial users about the need of waste segregation			N.A.	2	Swachh Bharat Mission
	Sub-total of possible financial implications for behavioural interventions							122.22
F	Sustainable Agriculture Practices							
F1	Promote modern cultivation techniques to optimise agricultural inputs and maximise outputs	Use of organic fertiliser and compost in place of urea in agricultural production	10,840 Ha (15%) of net sown area transitioned to organic fertiliser	5 (1.39%)	54,199 Ha(75%) net sown area transitioned to organic fertiliser	54 (12.06%)	885	National Mission for Sustainable Agriculture, Chief Minister's Manniyur Kaathu Mannuyir Kapom Scheme (CM MK MKS)
		Use of nano urea in place of urea in agricultural production	15% urea demand met via nano urea		Remaining 13% urea demand met via nano urea.		30.5	
		Total					915.5	
		Capacity building programmes can be conducted through Krishi Vigyan Kendra for creating awareness on climate resilient practices	Can be an ongoing initiative		Can be an ongoing initiative	NA	NA	National Innovations in Climate Resilient Agriculture (NICRA), Paramparik Krishi Vikas Yojana

Sr no	Key intervention	New energy matrix	Target for year 2030	Approximate annual mitigation potential in 2030 (ktCO ₂ e) (Percentage to bau gross emissions)	Target for year 2050	Approximate annual mitigation potential in 2050 (ktCO ₂ e) (Percentage to bau gross emissions)	Financial implications till 2050 (in Rs Cr)	Policies/fiscal measures by state and central govt.
		Establish local network of mini weather monitoring stations to monitor rainfall and temperature as well as to be able to forecast extreme weather conditions - this can help inform farmers of appropriate sowing, harvesting and irrigation timings	15 mini weather monitoring stations		Additional maintenance	NA	1.5	Krishi Decision Support System, Agricultural Infrastructure Fund (AIF)
F2	Livestock management	feed inputs for livestock - Tamarin plus and Harit Dhara to reduce methane emissions from enteric fermentation	30% manure managed to avoid methane emissions, balanced rationing adopted for 6,436 cattle (30%); improved feed supplements for 5,363 cattle (25%)	NA	90% manure managed to avoid methane emissions, balanced rationing implemented for 9,223 cattle (90%); improved feed supplements for 7,686 cattle (75%)	NA	103	Balanced Ration Programme (BRP)
	Total mitigation potential by 2030			5 (1.39%)	Total mitigation potential by 2050	54 (12.06%)		

7.2 Co-benefits of Decarbonisation

While the budget for decarbonising the agriculture sector, improving waste management, and enhancing carbon sequestration may appear substantial, these interventions offer significant cost savings and additional benefits, including:

Co-benefits of waste management

- In addition to reduced greenhouse gas (particularly methane) emissions, Human health will benefit due to methane's role in the formation of tropospheric ozone, which causes thousands of premature deaths and millions of chronic diseases every year
- Improvement of waste management systems is one of the best ways for cities to enhance local economies, real estate values, and quality of life.
- Improved wastewater systems reduce impacts on surface and groundwater, odours and carriers of communicable diseases.
- Wastewater management strategies can result in Increased local jobs.

Co-benefits of sustainable agriculture practices

Replacing synthetic fertilisers like urea with nano urea and organic fertilisers can increase the yield. Foliar application of nano urea along with basal application of recommended dose of conventional urea has yield advantage of 3–8% over conventional fertiliser application. Additionally, the average urea consumption for the period 2020 to 2023 in the Nilgiris district was 10,000 tonnes per year. At this consumption rate, the government would require ₹ 1400 Crores to finance the urea subsidy up to 2050 (at ₹2200 per 45 kg bag⁶⁴), which could be substantially saved by using nano-urea and organic fertilisers. Additionally,

- Balanced Rationing Programme (BRP) in livestock not only reduces methane emissions but also increases milk production with more fat and SNF which results in Increase in net daily income. According to National Dairy development board BRP resulted in increased lactation period (milk days) by average 26 days for cows and 50 days for buffaloes.
- Promoting natural/ organic farming, innovative and alternative fertilisers like Nano Fertilisers and organic fertilisers will help as follows.
- Improved soil health leads to increased nutrient efficiency and a safe environment due to reduction in soil and water pollution which in turn helps in the improvement of human health.

Co-benefits of increased agroforestry

- Agroforestry can provide effective alternate source of income for the farmers, increase and stabilise agricultural yields and reduce soil erosion, provide fuelwood, foods, fodder, basic construction materials, shade, medicines, etc.

7.3 Scope for Carbon Credits-based Financing for the Nilgiris District

The Paris Agreement recognises climate change as a collective challenge and calls on all countries to set emission targets through nationally determined contributions (NDCs). This shift towards collective action underscores the importance of carbon sinks (to offset residual emissions) as an effective measure to complement mitigation efforts in reducing emissions. Carbon markets play a crucial role, offering a market-oriented approach to incentivise the mitigation of carbon dioxide (CO₂) and other GHG emissions. They offer a structured framework for government and non-government entities to actively participate in the transition towards a low-carbon economy by earning carbon credits for engaging in sustainable practices and projects that decrease or offset GHG emissions. Projects can include forest conservation, reforestation, renewable energy installations (wind, solar, biogas), methane capture from landfills, and other energy efficiency projects.

The carbon credit market in India is currently in a developmental phase as the country moves towards the establishment of a formal domestic carbon trading system. In the past, Indian industries were familiar with the implementation of both compliance markets (such as Perform Achieve and Trade (PAT) – Energy Saving Certificates (ESCs) and Renewable Energy Certificates (RECs)), and voluntary (offset) projects such as Clean Development Mechanism (CDM) and other similar instruments. Notably, Indian agencies have registered the 2nd largest number of CDM projects globally. Under the PAT scheme, Indian units have been able to save more than 106 million tonnes of CO₂ emissions since 2015 till June 2024. India's carbon market is poised to play a crucial role in achieving its climate goals while contributing to global emission reductions, but regulatory and market structure development are still ongoing.

A new legislation was passed in 2022 to amend the Energy Conservation Act (ECA) of 2001, to empower the Central Government to specify a regulated carbon credits trading scheme. This scheme is envisioned to serve as a fundamental market-based instrument for financing mitigation projects in the country. It is expected that the enacted amendments to the ECA will accelerate progress on the decarbonisation of the Indian economy and enable it to meet the country's NDC commitments.

Carbon Credit Trading Scheme (CCTS)

In view of meeting the ambitious climate and emission reduction goals, a robust national framework for Indian Carbon Market (ICM) through a reliable national carbon credit electronic platform has been developed. Few highlights of this framework are as follows:

- The framework aims to compliment and support various entities by pricing their additional actions towards GreenHouse Gas (GHG) emission reduction, who are undertaking projects to decarbonise the Indian economy.
- Each carbon credit equals 1 tonne of CO₂ reduced or removed from the atmosphere, therefore purchases are always by the tonne.
- The ICM Framework has two key mechanism – Compliance mechanism and Offset mechanism for GHG reduction, thus providing a comprehensive approach to decarbonisation of the economy
- Compliance mechanism aims to address the emissions from energy use of industrial sectors
- Offset mechanism aims to incentivise the voluntary actions from entities not covered under the compliance mechanism.

Nilgiris District

The Nilgiris district is an ecologically abundant and sensitive region, rich in biodiversity, forest cover, agricultural activities and hosting the Nilgiris Biosphere Reserve (NBR) that provides ample opportunities for carbon credit projects. Under the CCTS, the district entities can participate in the offset mechanism to trade the carbon credits earned by offsetting GHG emissions in the district, thereby monetising the benefits. Under this scheme, an entity can register its project for GHG emission reduction, removal, or avoidance against the baseline, for the issuance of Carbon Credit Certificates (CCC) upon fulfilment of the eligibility requirements as per detailed procedure published by Bureau of Energy Efficiency (BEE) based on recommendations of National Steering Committee for Indian Carbon Market (NSCICM). The projects would be required to undergo a project cycle, including the different stages before becoming eligible for the issuance of CCCs. The Nilgiris district, already being Carbon Negative in the electricity sector with quite a number of renewable projects (hydro), can benefit from this offset mechanism to monetise the benefits of its decarbonisation projects.

It also has huge potential in the Agriculture and the Forestry sectors to generate CCCs and fund their future climate action projects/schemes. Community-based and community led projects can also benefit through participation in the carbon markets. The financial support can aid in enhancing resilience and creating livelihoods for the local population, especially tribal communities. For harder-to-finance initiatives like afforestation and land restoration, which often face challenges in attracting

investors due to lower returns, carbon credits offer a vital funding stream. By monetising these environmental benefits, community groups can secure necessary resources, making sustainable land management more economically viable and appealing to investors. The Carbon capture and sequestration projects, along with the transport sector and waste sector also have scope to leverage the CCTS mechanism to fund respective initiatives.

REDD+ (Reducing Emissions from Deforestation and forest Degradation + sustainable management of forests, conservation and enhancement of forest carbon stocks) is an international voluntary climate change mitigation framework developed by the United Nations Framework Convention on Climate Change (UNFCCC) that aims to reduce GHG emissions and to capitalise the role of forests as carbon sinks. REDD+ decisions were adopted in COP21, Paris, especially with the focus of empowering the developing countries to receive results-based payments for emission reductions. Clean Development Mechanism (CDM) is a United Nations -run carbon offset scheme that facilitates the developing countries to earn certified emission reduction (CER) credits (each equivalent to one tonne of CO₂) which in turn can be used to fund the climate change adaptation projects. This CDM mechanism also gives some flexibility to the developed countries in meeting their emission reduction targets.

Internationally, Verra (VCS) and the Gold Standard are two of the most recognised and rigorous certification frameworks in the voluntary carbon market (VCM), ensuring that carbon credits represent genuine, verified emission reductions or removals. The main differences between them lie in the methodologies they use, their emphasis on co-benefits, and the types of projects they tend to certify.

Projects that reduce or remove greenhouse gases (e.g., reforestation, renewable energy, or methane capture) can apply for certification under a carbon standard. Once certified, these projects generate carbon credits, which could be sold to buyers who want to offset their emissions.



8. Monitoring and Evaluation of Decarbonisation Plan

Monitoring and Evaluation (M&E) is essential for ensuring effective implementation, tracking progress, and assessing impacts on resilience and sustainability of the Nilgiris Decarbonisation Plan. In a shifting climate landscape, a robust M&E framework provides structure to evaluate success, address new challenges, and guide data-driven improvements. This section outlines measurable indicators to monitor outcomes, optimise resources, and align actions with Nilgiris's climate resilience goals, supporting continuous, community-focused adaptation. This section also identifies key stakeholders and institutions to be engaged in the monitoring and evaluation process.

8.1 Suggested Indicators

The following table provides indicators across key themes of the decarbonisation plan. The indicators provided as part of this plan are not exhaustive, and should be updated periodically to better reflect the outcomes achieved as part of the implementation of climate action suggestions.

Indicators can be against an established baseline (year when the implementation starts) and then progress of the implementation can be measured annually or bi-annually as per decision of the Monitoring Committee.

Category	Proposed Interventions	Broad Suggested Indicators	Broad Anticipated Outcomes
Transport Sector	Achieve a zero-emission public and private transportation system by 2050 - Promote electric vehicle (EV) adoption and set up EV charging stations - Electrify public transportation (buses, 3W, 4W passenger vehicles)	Vehicle category wise number of EV registered/% of EV in the New sales Annual change in fossil fuel sales in the district	Medium term: 50% new EV sales for 2W, 3W, 4W and buses Reduction in fossil fuel consumption Long term 100% EV adoption for 2W, 3W, 4W, and Buses Fossil fuel phase out
Electricity	Transition to 100% Renewable Energy in the District: - Rooftop installation - Agro Photovoltaic - Captive RE	Annual new RE capacity addition Rooftop capacity in the District/% No of households having rooftop	Medium term: Completion of Potential assessment of Renewable energy sources. Long term: Replacement of complete fossil based captive capacity to Renewable energy and rooftop solar and alternative sources..
Agriculture	Transition to Solar pumps: Replace 100% of diesel pumps with decentralised solar pumps under PM KUSUM scheme. Transition from Diesel Tractors and agro machineries to electric based machineries	Percentage of Electric Tractors in New Sales Number of farmers benefiting from solar pumps installation/New Number of pumps installed	Medium term: Targeting at least 30% of new tractor sales as electric. At Least 50% of new pumps to be solar. Long term: Achieve 90% electrification of tractors. 100% of new pump sales as solar.
Industry	Energy Efficiency in Tea Manufacturing: Replace existing heaters through waste wood-based air heaters in tea manufacturing units. After 2030, Achieve full decarbonisation of tea production through electric air heaters	Annual Reduction in Fuel Consumption (tons or litres of fuel oil/wood) Number of Tea Manufacturing Units Using Renewable Energy Sources New Electric based industrial heaters sales	Medium term (2035): Switch at least 50% of units to electric based heating. Long term (2050): Switch to 100% electric based heater in tea manufacturing units.

Buildings	Shift to Energy Efficient residential appliances. Adoption of LED based lighting Replacement of Diesel generators by clean source of electricity backup Mandate energy efficiency retrofits in commercial buildings	Number of five star rated appliance sales in new appliance sales. Number of DG sets replaced with electricity based alternatives. Number of residential/ commercial buildings installing rooftop solar. Number of Households purchasing Electric or Induction Cooking.	Medium term: Adoption of 100% LED in households and streetlights. 60% appliances or more to be 5 star rated. Adoption of ~50% Commercial buildings retrofits for energy conservation. Long term: 100% adoption of super efficient appliances in households. More than 50% adopt Electric cooking. 100% Commercial buildings adopt building retrofits.
	Ensure 100% segregation and collection of waste at source	Percentage of households (urban+rural) from where segregated waste is collected Percentage of commercial and institutional/ administrative establishments from where segregated waste is collected Number of EVs in use for waste collection Percentage of collected dry waste recycled/processed (urban+rural) Percentage of collected wet waste processed (urban+rural) Number of waste collection bins installed at strategic locations Number of operational e-waste collection points established Percentage of localities covered under monthly collection of e-waste	Efficient waste collection and processing, increased recycling, and enhanced sanitation services contribute to cleaner and healthier communities, and reduce emissions by preventing waste to reach landfills
Solid Waste Management			

	Management of Organic Waste	1. Setting up of waste management facilities	Number and installed capacity of composting centres established	
		2. Encourage and promote composting, vermi-composting and biogas plants at residential and commercial entities (hotels/resorts/homestays).	Compost sold	
		3. Facilitate and conduct Behaviour Change Communications workshops on proper disposal of solid waste.	Number and installed capacity of vermicomposting plants	
			Capacity of waste management plants (TPD)	
	Management of C&D waste		Number and installed capacity of biogas plants	
	Management of Legacy waste		Number of C&D collection and transfer stations	
			Total installed capacity of C&D waste management plants (TPD)	
			Amount of recycled material sold/reused (concrete, ceramics, iron, wood, etc.,)	
	Waste management through circular economy		Quantity of legacy waste in all the identified dumpsited underwent remediation	
			Number of eco parks	
Water and Wastewater Management	Management of water bodies	1. Marking and bund construction around the boundaries of the water bodies.	wastewater nalahas emptying into water bodies and Interception and Diversion (I&D) works undertaken	Improved water access, groundwater conservation, and rejuvenated water bodies support sustainable water management and resilience.
		2. Restoration of wetlands	Water quality assessment test for the lakes	
		3. Restoration and softscaping of lakes	Amount spent on lake restoration/ dredging	
			Number of employment generated for lake restoration/ dredging	
			Number of wetlands rejuvenated/restored	
			Number of lakes restored, dredged and softscaping carried out	
				Reduced GHG emissions from wastewater, and enhanced sanitation services contribute to cleaner and healthier communities

	Groundwater management	Number of public buildings (Government offices, government schools, institutes, etc.) having functional rainwater harvesting mechanism	
		Number of PRI buildings having functional rainwater harvesting mechanism	
		Percentage of public/PRI buildings covered with RWH mechanism	
		Number of hotels/lodges/guest houses with RWH structures	
		Number of new buildings with RWH structures	
	Wastewater management	Percentage (length) of roads with proper storm water drain coverage	
		Number of silt traps installed at outfall point of drains	
		Number of trench grates installed along the curb of the road in residential and civil line area	
		Number of households connected to sewage system	
		Percentage of households connected to drainage/sewage network	
		Capacity of installed, operational, and maintained STPs	
		No. of DEWATS installed in the villages within the planning area	
		Capacity of installed, operational, and maintained ETPs	
		Number of rural households with septic tank and FSTP	

Tourism	Incorporate sustainable waste management awareness with tourism activities	Number. of capacity building workshops organised for hospitality professionals (waste, management)	Increased sustainability practices in hospitality, including water management, waste management and energy efficiency, enhance eco-friendly tourism experiences.
		Number of 'Swacchta Saarthis' deployed at key locations	
		Number of hotels/lodges/ rest houses with IEC material on waste segregation and disposal displayed	
		Number of solar water kiosks installed and operational at public places	
		Percentage of hotels/ lodges/guest houses with sustainable infrastructure (ECBC compliant,etc.)	
Sustainable Agriculture	Increased use of organic fertilizers, promoting balanced rationing for livestock and alternate wetting and drying of paddy fields	Quantity of nano urea and organic fertilisers used annually (in tonnes)	Increased sustainability Enhanced crop productivity Improved soil quality Reduced Emissions
		Quantity of improved feed supplements incorporated in the livestock diet (in tonnes)	
		Annual productivity of crops	
		Agriculture area affected by extreme weather events (Hectare) and change in production of crops (tonnes)	
		Area of cultivated rice under multiple aeration and system of rice intensification (SRI)	
Enhancing Carbon Sequestration	1. Promoting social and agroforestry 2. Enhancing Carbon stock density through reforestation and afforestation.	Percentage increase in tree cover in the planning area since baseline year	Expanded green cover, enhanced carbon sequestration leading to reduced GHG emissions, improved biodiversity conservation, and increased urban green spaces for environmental and social benefits.



9.

Conclusion

The Nilgiris Decarbonisation Action Plan presents a technically robust, sector-specific roadmap for transitioning the district towards carbon neutrality, leveraging both emissions reduction and land-based carbon sequestration strategies. With an already carbon-neutral electricity profile driven by hydroelectric power, the district is well-positioned to lead subnational climate action.

Under the Aggressive Effort Scenario (AES), Nilgiris can reduce economy-wide gross emissions by 62% and achieve net-negative emissions of 320 ktCO₂e by 2050, primarily through decarbonising transport, buildings, and agriculture, alongside restoration of grasslands and enhancement of forest carbon stock density. Adoption of clean technologies, energy efficiency, fuel switching, and circular waste practices are key levers, supported by targeted electrification and sustainable land-use interventions. Through rooting these solutions within communities, the district can generate local ownership and thereby, scalable impact.

The plan aligns with Tamil Nadu's climate targets and India's Net Zero commitment, and demonstrates how a district-level, data-driven, and community-inclusive approach can operationalise deep decarbonisation while ensuring ecological and economic resilience.

The success of this plan hinges on robust implementation, continuous stakeholder engagement, and sustained collaboration between government agencies, industries, and local communities. For the implementation of this plan, a dedicated project management unit (PMU) could be formed which will monitor and provide the implementation support to the overall execution of the plan.

Further, the decarbonisation plan should be reviewed and updated periodically to incorporate the latest advancements in technology, changes in policy frameworks, and evolving socio-economic conditions. This will ensure that the strategies remain relevant and aligned with the district's long-term vision.

10. Annexure

Annexure 1: Methodology of Climate Variability

Rainfall variability has been analysed for the **Southwest monsoon (June to September)** and **Northeast monsoon (October to December)** seasons. Additionally, the precipitation extremes, such as the number of rainy days, Consecutive Dry Days (CDD), and heavy rainfall amounts (RX1DAY, RX5DAY), have been analysed.

Rainy day: A rainy day, according to the IMD, is defined as any day receiving >2.5 mm rainfall.

Consecutive Dry Days (CDD): Maximum number of consecutive dry days per period with daily precipitation amount of less than 1 mm.

RX1DAY: Highest 1-Day precipitation amount.

RX5DAY: Highest consecutive 5-Day precipitation amount.

Temperature has been analysed for the summer season (March to May) and the winter season (December to February). The temperature extremes such as Warm days (%), Cold days (%), Heat wave duration and Frequency have been analysed.

Warm days: Percentage of days when maximum temperature greater than the 90th percentile

Cold days: Percentage of days when maximum temperature less than the 10th percentile

HWDI: The number of heat wave periods not less than 5 days.

HWFI: Maximum number of consecutive days per year when the daily maximum temperature is above the 90th percentile.

Climate variability refers to variations in the mean state of the climate parameters (temperature, rainfall, etc.) and other statistics (such as standard deviations, statistics of extremes, etc.) on temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or due to variations in natural (e.g. solar and volcanic) external forcing (external variability).

The study analyses historical climate information and projects climate for a future period using global climate models. The simulations of precipitation and temperature have been used for 1986 to 2005 (historical period) while projections have been considered over four different epochs 2021-2040 (2030s), 2041-2060 (2050s), 2061-2080 (2070s) and 2081-2100 (2090s) under medium (RCP4.5) and high (RCP8.5) emission scenarios.

Annexure 2: Future Climate Projections for Nilgiris District-Methodology

To examine the future climate projections over the district, the global NEX-GDDP (0.25 x 0.25) Bias corrected high resolution statistically downscaled dataset derived from 20 GCMs under CMIP5 and across two greenhouse gas emission scenarios, RCP4.5 and RCP8.5, have been used

in this analysis. The precipitation and temperature over Nilagiris from 1986 to 2005 have been simulated using the Multi-Model Mean (MMM). Nilagiris district may experience a projected increase in the quantum of rainfall in the monsoon months and the season as a whole in different epochs (2021-2040, 2041- 2060, 2061-2080, and 2081-2100) under medium (RCP4.5) and high (RCP8.5) emission scenarios.

Annexure 3: Methodology- GHG Emission Profile- Nilgiris

The GHG inventory has been developed for the period 2005 to 2022, accounting for carbon-dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) emissions. The inventory covers the four emission sectors, namely, Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry & Other Land Use (AFOLU) & Waste, and relevant sub-sectors, as per the IPCC methodology and guidelines. Since Nilgiris district does not have sizable industrial and processing units, the emission from the IPPU sector is estimated from lubricant use.

The GHG inventory follows a robust approach based on information received from relevant line departments of the Government of Tamil Nadu, and reports published at national and state level, as detailed in **Table A1**. The emission factors are extracted from Govt. of India's inventory submissions.

The GHG estimation is based on IPCC Tier 1 (T1) and Tier 2 (T2) approaches. The best effort was made to source activity data and emission factors at the state-level. Although the T2 approach was prioritized, T1 has been followed in the absence of country-specific emission factors. The sector-wise approach is as detailed in **Table A1**.

The inventory also estimates the Global Warming Potentials (GWP) for CH₄ and N₂O based on the GWP of greenhouse gasses for a 100-year timeframe, as per IPCC AR2 (IPCC, 1995).

Table A1: Sector-wise Data source, Tiers, and Assumption Used for Emission Estimations

IPCC ID	Category	Data source	Approach	Assumptions
	ENERGY			
1A 2	Industrial Energy	Fuel consumption data of FO/LSHS, LDO, and HSD was obtained from the Petroleum Planning and Analysis Cell (2006 to 2023) Bitumen, FO/LSHS, HSD, Kerosene, LDO, LPG, Lubes and Greases, Motor Spirit, Others.	T2	- The emissions from overall Industrial energy were estimated due to the unavailability of industry-wise fuel consumption data. - The district-level FO/LSHS and LDO data from the PPAC were considered solely for the industries category. - The district-level HSD consumption data of Industries was not available. Therefore, the state-level percentage share of Diesel used for Industrial purpose obtained from PPAC report (2013¹ and 2021²) was applied on overall HSD consumption data (obtained from PPAC) to estimate the district-level fuel consumption data.
1A3b	Road Transport	Fuel consumption data of Motor Spirit and HSD was obtained from the Petroleum Planning and Analysis Cell (2006 to 2023)	T1, T2	Due to unavailability of the district-level fuel consumption data, the National-level percentage share of fuel and the state-level percentage share of Motor Spirit and Diesel used for the Road Transport sector (obtained from PPAC reports 2013 and 2021) was applied to the overall fuel consumption

¹ All India Study on Sectoral Demand on Diesel and Petrol , Petroleum Planning and Analysis Cell (2013)

https://ppac.gov.in/uploads/rep_studies/1674814577_201411110329450069740AllIndiaStudyonSectoralDemandofDiesel%20%282%29.pdf

² All India Study on Sectoral Demand on Diesel and Petrol , Petroleum Planning and Analysis Cell (2021) accessed from the hard copy.

				data to estimate the district-level fuel consumption data.
1A4	Other Sectors	Fuel consumption data of Kerosene, and HSD was obtained from the Petroleum Planning and Analysis Cell (2006 to 2023)	T1, T2	• For the Commercial sector, the district-level LPG Fuel consumption data was estimated by applying the National-level percentage share LPG on the overall District-level fuel consumption data. • While the HSD data was estimated by applying the National-level retail and private sales percentage share and state-level percentage share Diesel consumed for the Other sector along with the percentage share of Diesel consumed in the Commercial sector on the overall district-level fuel consumption data. • For the Residential sector, the district level Kerosene and LPG Fuel consumption data were estimated by applying the National-level percentage share LPG on the overall District-level fuel consumption data respectively. • While the HSD data was estimated by applying the National-level retail and private sales percentage share and state-level percentage share Diesel consumed for the Other sector along with the percentage share of Diesel consumed in the Residential sector on the overall district-level fuel consumption data.

	AFOLU			
3A	Livestock	2010-11 to 2014-15, 2019-20 to 2021-22 Data received from the district	T1, T2	- The cattle data for the year 2017 was estimated by apportioning 2012's percentage share of Category-wise and age-wise cattle data on the total 2017's cattle data. - The remaining years between 2012 and 2017 were estimated using the Interpolation method. - The livestock emissions for the years 2005 to 2010 were estimated using the CAGR method based on 2011 to 2022 emissions.
	Biomass Burning in Forestland	2012 to 2022 data received from Forest Department of Tamil Nadu	T2	The Biomass Burning in Forestland has not been estimated for years 2005 to 2011 as the data for the said years was not available.
3C1b	Biomass burning in cropland	Rice- 2004-05 to 2019-20 Wheat- 2011-12, 2016-17 Cotton- 2007-08 to 2014-15 Sugarcane-2004-05 to 2019-20 Rapeseed and mustard- 2019-20 Groundnut-2009-10, 2010-11, 2013-14 to 2017-18 Ragi- 2006-07 to	T1	Wherever direct data was not available, suitable statistical methods were applied for estimation like CAGR and average.

		2009-10, 2012-13, 2019-20 Small millets- 2004-05 to 2007-08, 2016-17 Directorate of Economics and Statistics, Department of Agriculture and Farmers Welfare, GoI		
3C7	Rice Cultivation	2004-05 to 2019-20 Directorate of Economics and Statistics, Department of Agriculture and Farmers Welfare, GoI	T2	• The percentage of rice cultivated area under different water management regimes of Tamil Nadu is assumed to be the same for Nilgiris district. • Wherever direct data was not available, suitable statistical methods were applied for estimation like CAGR
3C4 & 3C5	Agriculture Soils	Urea and Nitrogen consumption data 2010-11 to 2014-15, 2019-20 to 2021- 22 Data received from district 2016-17 data from District Statistical handbook 2016-17 2015-16 from District Statistical Handbook 2015-16	T1 and T2	• Estimates are based on the assumption that the measurement units of Nitrogen consumption are in metric tons and not thousand tons as seen in the shared activity data from the district. • Wherever direct data was not available, suitable statistical methods were applied for estimation like CAGR and IR

		2017-18 from District Statistical Handbook 2017-18 2018-19 urea data from Tamil Nadu Government portal		
3B1	Forest Land	a) Total Forest Cover: 2011-12 to 2013-14 and 2015-16 to 2022-23 from the Nilgiris District Statistical Handbook. b) Carbon Stock Density of Tamil Nadu for the years 2015, 2017 and 2019 from FSI 'India State of Forest' reports.	T2	c) <u>Total Forest Cover:</u> i. Based on the expert input the forest cover (km²) is taken as a sum of 'forest area', 'land under misc. tree crops & groves' and 'permanent pastures and other grazing lands' (<i>Source: Nilgiris District Statistical Hand Books</i>), since the forest cover as per FSI 'India State of Forest' report shows a steep decline during the study period. Removal of invasive tree species such as Lantana, Black wattle, Scotch broom, and Gorse could contribute to this steep decline in forest cover. ii. For the years 2005 to 2010, the forest cover data was assumed to be the same as of 2011 since data was not available, while for the year 2014-15, data was estimated using the interpolation method. d) <u>Carbon Stock Density (CSD):</u> i. The Carbon Stock Density is available only at state level in the FSI report. Since the

				overall geography of Tamil Nadu state is dry and arid and does not reflect the geography of the Nilgiris District, which consists of Tropical evergreen forest, Sholas and grasslands, Savannah woodland, etc. that have a higher tree density, a carbon stock of 15 tonnes/ hectare was added to the Carbon Stock Density of Tamil Nadu to deduce the Carbon Stock Density of Nilgiris district based on inputs from the forest department(further detailed in Annexure 5)
3B2,3B3, 3B5 & 3B6	Land Use (except Forest land)	2005-06, 2011-12 and 2015-16 of LULC from BHUVAN		In the absence of the Land Use Land Cover Change (LULC) matrix, the emissions from LULC were estimated by taking the difference between 2005-06 and 2011-12, and 2011-12 and 2015-16 for the categories of Agricultural Land, Other Land, and Settlements.
	IPPU			
2D1	Lubricant Use (Non energy products from fuels and solvent use)	Lubricant Consumption data received from the Petroleum Planning and Analysis Cell (2006 to 2022)	T1	

	Waste			
A	Solid Waste Disposal	Population data: census 1951, 1961, 1971, 1981, 1991, 2001, 2011 Per capita generation: Waste Generation and Composition for 2004-05, Central Pollution Control Board (CPCB), Annual Review Report: 2014-15, CPCB DOC: Integrated Modeling of Solid Waste in India (March 1999) CREED Working Paper Series no 26 and CPCB, 1999 2005 CPCB and NEERI study in 59 cities The Central Public Health and Environmental Engineering Organisation (CPHEEO), Ministry of Urban Development, GoI (2015): Manual on Municipal Solid Waste Management-2016, Table I.6	T1, T2	• Proportion going to landfill- municipality-level proportions from 2005-2022 was considered to estimate the emissions • Estimates are based on district-level values of per capita waste generation. • State-level DOC proportions were used to estimate GHG emissions due to lack of data at the district level

4D1	Domestic Wastewater Treatment and Discharge	Population data: census 2001, 2011 Protein intake: MOSPI BOD: National Environmental Engineering Research Institute (NEERI). 2010: Inventorisation of Methane Emissions from Domestic & Key Industries Wastewater – Indian Network for Climate Change Assessment STP: Availability and Type of Latrine facility in Rural Households", Census report 2011 Urban degree of utilization: Census of India, Ministry of Home Affairs, Government of India		Estimates are based on state-level values and proportions of BOD, STP status, Protein intake, and urban degree of utilisation due to a lack of data at district level
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Annexure 4: Assumptions used for projections

The projections for livestock are based on the following assumptions:

- The livestock data for the years 2010-11 to 2014-15 and 2016-17 to 2021-22 were obtained from the Nilgiris District Department and Statistical Handbook. For the years between 2010-11 to 2016-17, the cattle population was Interpolated (IR). For 2022, the livestock population data was estimated based on the CAGR method. The livestock emissions for the years 2005 to 2010 were estimated using the CAGR method based on 2011 to 2022 emissions.
- The livestock emissions for the period 2023 to 2050 were forecasted based on the emissions for the period 2019-2022.

Assumptions used in projecting fertiliser consumption data are as follows:

- Fertiliser consumption (Nitrogen) data for the year 2010-11 to 2017-18 and 2019-20 to 2021-22 was extracted from the district department and Statistical Handbook. 2005-06 to 2009-10 and 2018-19 data were calculated by applying CAGR and Interpolation (IR). Fertiliser consumption for the period 2022 to 2050 was forecasted based on 2014 to 2021 data.
- Urea consumption data for the year 2010-11 to 2023-24 was extracted from the district department and Statistical Handbook. 2005-06 to 2009-10 were calculated by applying CAGR. Fertiliser consumption for the period of 2024 to 2050 was forecasted based on 2005-2023 data.

Annexure 5:

1) Carbon Stock Density

Region	Carbon Stock Density (tonnes/hectare)		
	2015	2017	2019
Tamil Nadu	87.26	82.23	81.22
Kerala	125.92	100.72	96.7
The Nilgiris District (<i>estimated</i>)	102.26	97.23	96.22

2) Agriculture Soils

Year	Organic fertilizer substituted for total nitrogen and urea		Nano urea substituted for urea	
	MES	AES	MES	AES
2030	10%	15%	25%	35%
2035	20%	30%	50%	70%
2040	30%	45%	75%	100%
2045	40%	60%	100%	100%
2050	50%	75%	100%	100%

3) Domestic Wastewater

Year	Proposed Capacity of Centralised wastewater treatment for urban areas and twin-pit septic tanks and FSTP at Gram Panchayat cluster level for rural populations to treat 55 MLD waste generated in Nilgiris	
	MES (MLD)	AES (MLD)
2030	15	25
2040	20	30
2050	20	

Summary Table: Sector-wise BCS, MES and AES Emissions/Removals

Sector	GHG Sources and Sink Categories	2050		
		BCS kt CO ₂ e	MES kt CO ₂ e	AES kt CO ₂ e
	Oil	213	159	106
	Biomass	9	4	0
	Cooking Gas	108	73	38
	Energy Total	330	237	144
AFOLU	Aggregate Sources and Non-CO₂ Emissions Sources on Land	72.2	36.2	18.2
	Agriculture Soil	71.97	35.98	17.99
	Biomass burning in cropland	0.005	0.005	0.005
	Rice Cultivation	0.21	0.21	0.21
	Land emissions	0.005	0.005	0.005
	Land removals	-323	-437	-498
	Net Land Emissions/Removals	-323	-433	-492
	Livestock	9.17	9.17	9.17
	AFOLU total	-241.9	-391.4	-470.3
Waste	Solid Waste Disposal	1.8	1.8	1.8
	Domestic Wastewater	32.12	0.07	0.07
	Industrial Wastewater	Not estimated	Not estimated	Not estimated
	Waste Total	34	1.9	1.9
Gross Emissions		448	275	172
Net Emissions		124	-162	-326

Annexure 6

Existing policies relevant for decarbonisation of energy and non-energy sectors

The table below highlights several Central and State Government schemes contributing to decarbonisation of Nilgiris district.

Policy/Scheme	Key Highlights
Electricity Sector	
Pradhan Mantri Surya Ghar Muft Bijli Yojana	Under the scheme, households will be provided with a subsidy to install solar panels on their roofs. The subsidy will cover up to 40% of the cost of the solar panels. The scheme is expected to benefit 1 crore households across India.
Renewable Energy Targets	India aims for 500 GW of non-fossil fuel capacity by 2030 and has set aggressive targets for wind, hydro, and biomass energy. Declaration of trajectory for Renewable Purchase Obligation (RPO) up to the year 2029-2030.
Carbon Pricing Mechanisms	Through initiatives like renewable energy certificates (RECs) and carbon markets. To facilitate achievement of India's NDC targets, the Government of India has initiated the development of a unified carbon market mechanism, Indian Carbon Market (ICM). ICM will mobilise new mitigation opportunities through demand for emission reduction credits for both public and private entities.
Agriculture Sector	
One Village One Crop	This scheme aims in making villages self-sufficient by developing agriculture as the main occupation. The scheme also aims to convert fallow lands into cultivable lands thereby indirectly helping villages adapt to climate change. 1. Implementing a crop insurance scheme to help farmers recover from income loss due to natural disasters 2. Developing climate-smart villages to demonstrate climate change mitigation technologies
Chief Minister's Manniyur Kaathu Mannuyir Kappom Scheme (CM MK MKS)	CM MK MKS aims to achieve sustainable and chemical free agricultural practices through 1. Distribution of Green Manure seeds 2. Vermicompost pits and beds for farmers

Policy/Scheme	Key Highlights
Kalaigharin All Village Integrated Agriculture Development Programme (KAVIADP)	KAVIADP strives to increase the economic status of farmers by bringing fallow lands under cultivation and increase the cultivable area by creation of new water sources. 1. To increase agricultural production and productivity.
National Agriculture Development Programme (NADP)	NADP strives to diversify and rejuvenate the agriculture sector. 1. Special Package for transforming fallow lands to cultivable lands (millets & pulses) 2. Solar Powered fencing for mitigation of crops from damage due to human-animal conflicts
Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Scheme (PM-KUSUM)	PM-KUSUM strives to offset agriculture sector fuel (diesel) usage by solarisation and thereby enhancing income of farmers. 1. 30% - 50% of total cost for installation of standalone solar pumps or solarisation of existing grid connected pumps
Bharatiya Prakritik Krishi Paddhati (BPKP)	BPKP aims at promoting on-farm biomass recycling, use of cow dung-urine formulations and exclusion of synthetic chemical inputs. 1. Financial assistance of Rs 12200/ha for 3 years is provided for cluster formation, capacity building and continuous hand holding by trained personnel, certification and residue analysis 2. Dry lands, rainfed areas and tribal areas are to be given preference. 3. Small and marginal farm holders, including tenant farmers, to be the preferred target group
National Mission for Sustainable Agriculture (NMSA)	NMSA focuses on climate-resilient farming practices, efficient irrigation, and promoting organic farming. NMSA also aims to make agriculture more productive, sustainable, remunerative and climate resilient by promoting location specific Integrated / Composite farming systems.
Soil Health Card Scheme	This scheme promotes balanced fertilisation and reduces excessive chemical fertiliser use. In the form of soil card, farmers will get a report containing all the details about the soil of their particular farm. This will make farmers aware of soil management practices and help them plan the future of their crop and land.

Policy/Scheme	Key Highlights
Industries Sector	
Tamil Nadu Startup Seed Grant Fund (TANSEED) / Tamil Nadu Startup and Innovation Mission (TANSIM)	TANSEED is the flagship scheme of GoTN to support startups by providing incubation support and bridging the gap in fund requirements through seed fund initiatives. 1. Grant program for innovative enterprises in 3 focus areas of agriculture, climate action and livelihood. 2. Key focus on Feeds, Fodder, Animal nutrition and Waste to Value / Circular economy
Perform Achieve and Trade (PAT) Scheme	A market-based mechanism to enhance energy efficiency in large industries and enable them to trade surplus energy efficiency certificates. Currently, PAT Cycle VII is in progress for the FY 2022-23 to the FY 2024-25, covering 707 designated companies with an overall energy saving target of around 8.5 million tonnes of oil equivalent (MTOE) in 9 major energy intensive sectors.
Green Industry Incentive (Tamil Nadu Industrial Policy 2021)	Industrial projects earning IGBC green certification are eligible for incentives under the latest industrial policy of GoTN. 1. Industrial projects undertaking green initiatives for recycling waste and water for captive use shall be eligible for a 25% subsidy on the cost of setting up such environmental protection infrastructure subject to a limit of Rs. 1 crore
National Bio-Energy Programme (NBP)	NBP encourages the use of biomass and waste-to-energy plants with the objective of providing additional income to rural households. The programme includes specific sub-schemes for establishments of Waste to Energy, Biomass and Biogas generation plants or units.
Energy Conservation Building Code (ECBC)	ECBC mandates energy-efficient construction practices in commercial buildings. ECBC defines the norms of energy performance for various building components and categories, taking the climatic aspect into consideration. The idea is to lower building energy requirement without affecting the function, comfort, health or productivity of the occupants.

Policy/Scheme	Key Highlights
Green Steel Initiatives	Promotion of hydrogen-based steel production and energy efficiency in the iron and steel sector. Encourage the sector to adopt Best Available Technologies (BAT) globally in modernisation and expansion projects. The Carbon Credits Trading Scheme also facilitates to incentivise the emissions reduced by iron and steel companies.
Transport Sector	
Tamil Nadu Electric Vehicle (EV) Policy 2023	For promoting EVs and adjoining infrastructure in the state, the latest EV policy of GoTN provides incentives for various categories. 1. Special demand side incentives for commercial vehicles apart from regulation and concession measures for promotion of EVs 2. Incentives for charging stations to develop widespread infrastructure and tariff concessions
PM- E Drive	This scheme aims to expedite adoption of electric vehicles (EVs) through upfront financial incentives 1. Aadhar authenticated e-voucher to avail demand incentives 2. 3679 crores for private EVs ; 500 crores for e-ambulances ; 4391 crores for 14, 028 e-buses 3. 70,000+ fast chargers for EVs at 2000 crores ; 500 crores for incentivising e-trucks
Vehicle Scrapping Policy	Vehicle Scrappage Policy of GOI aims to reduce air pollution, improve road safety and stimulate vehicle sales. Automobile OEMs to provide discount on purchase of new vehicles against certificate of deposit (scrap) 1. Scrap value given by scrapping centre would be at 4-6 % of ex-showroom price of new vehicle 2. Waiving off registration fee and concession on tax for new vehicle by state government
Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME)	The current phase (II) of the FAME scheme focusses on electrification of public and shared transportation. It aims to provide subsidies and demand incentives to promote electric vehicles (EVs) and develop EV infrastructure for around 7090 e-Buses, 5 lakh e-3wheelers, 55000 e-4wheeler passenger cars and 10 lakh e-2wheelers.
National Green Hydrogen Mission	This mission aims to develop green hydrogen technologies for decarbonising heavy industries and transportation. The mission strives to develop India as the global hub for production, usage and export of Green Hydrogen and its derivatives.

Policy/Scheme	Key Highlights
Railway decarbonisation	India targets achieving net-zero emissions for its railways by 2030 through electrification and renewable energy use. Indian Railways is setting up dedicated freight corridors (DFCs) across the country, where the first phase targets an emission reduction of 457 million tonnes of CO ₂ over a 30 year period.
Urban Development Sector	
Kalaigharin Nagarpura Mempattu Thittam (KNMT)	KNMT aims to fulfil infrastructural gaps in municipalities and town panchayats until Urban Local Bodies (ULB) level. 1. Funding for rejuvenation of water bodies, Solid Waste Management (SWM) infrastructure development including greening the vehicle fleet, construction of public toilets and parks etc.
Ujjwala Scheme	Promotes the use of cleaner cooking fuels like LPG, reducing reliance on traditional biomass. 9.6 crore LPG connections have been realised through the scheme till 2022, and currently an additional 75 lakh connections have been released.
Namakku Naamae Thittam (Urban)	This scheme improves the self support mechanism of public participation in creating and maintaining community infrastructure.
National Electric Mobility Mission Plan (NEMMP)	NEMMP encourages EV adoption in cities to reduce emissions from urban transport. This is aimed through incentivising the buyers or reimbursing the reduced price of the manufacturer.
Waste Sector	
Swachh Bharat Mission (SBM)	SBM is a country wide campaign focussing on sustaining the Open Defecation Free (ODF) status while also promoting sustainable solid and liquid waste management. 1. 100% scientific processing of Municipal Solid Waste 2. Remediation of all legacy waste dumpsites 3. Open defecation free status with no untreated faecal sludge or used water is discharged into environment

Policy/Scheme	Key Highlights
Galvanising Organic Bio-Agro Resources Dhan (GOBARDhan)	GOBARDhan scheme aims to convert waste to wealth towards promoting a circular economy by building a robust ecosystem for setting up Biogas/Compressed Biogas (CBG) and Bio-Compressed Natural Gas (CNG) plants. 1. Any government/ private entity operating or intending to set up a Biogas/ CBG/ Bio CNG plant can apply. 2. Supporting villages to efficiently manage their agricultural and cattle waste thereby keeping the surroundings clean. 3. Eligible entities are classified into Individual household model, Cluster model, Commercial model and Community model.
Waste to Wealth Mission	This mission aims at strengthening the waste management system in India by identifying and validating innovative technology solutions and models to achieve a zero-landfill and zero-waste nation. The mission aims to achieve this through effective management of solid waste and development of robust waste-to-energy and composting facilities.
Water Resources and Forest Sector	
Jal Jeevan Mission (JJM)	JJM envisions to provide safe and adequate drinking water through individual household tap connections. 1. Functional Household Tap Connections with 55 LPCD capacity and ensure long term sustainability with potable water 2. Construction of Water treatment plants and strengthening of distribution / collection network infrastructure
Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	PMKSY focusses on sustainable water conservation practices exploring the feasibility of reusing treated municipal wastewater to the extent possible. 1. Creation and rejuvenation of traditional water storage systems like Eri (Lakes) and Ooranis (Small Ponds) at feasible locations 2. Capacity building, entry point activities, ridge area treatment, drainage line treatment, soil and moisture conservation, nursery raising, afforestation, horticulture, pasture development, livelihood activities for the asset-less persons and production system & micro enterprises for small and marginal farmers etc. 3. Effective rainfall management like field bunding, contour bunding/trenching, staggered trenching, land levelling, mulching etc.

Policy/Scheme	Key Highlights
Amrit Dharohar Scheme	This scheme promotes unique conservation values of Ramsar sites. These sites have multidimensional roles to play including enhancement of carbon sinks, buffer landscape from extreme events and provide water and food security. 1. Encourage optimal use of wetlands, and enhance biodiversity, carbon stock, eco-tourism opportunities and income generation for local communities 2. Key activities and components of the scheme include Species and Habitat conservation, Nature tourism, Wetlands livelihood, Wetlands carbon.
National Afforestation Program (NAP)	NAP is a centrally sponsored scheme aiming to restore degraded forests and develop forest resources by supporting large-scale reforestation and afforestation projects.
Green India Mission (GIM)	GIM aims to protect, restore and enhance India's forest cover, improve ecosystem services and enhance carbon sinks thereby responding to climate change. Key activities include enhancing tree cover in urban and peri-urban areas, eco-restoring open forests and grasslands, restoring mangroves and abandoned mining areas etc.
Agroforestry Policy	This policy promotes integrating trees into agricultural landscapes to sequester carbon and boost farmer income. It also involves promoting climate resilient cropping and farming systems thus conserving environment and biological diversity.

Endnotes

- 1 Scheme valid till March 2026, unless extended.
- 2 Scheme valid till December 2025, unless extended.
- 3 https://tnpcb.gov.in/PDF/About_Us/Announcementgos/GONo116_16625.pdf
- 4 <https://www.cag.org.in/blogs/leaf-cup-journey-through-energy-efficient-tea-processing>
- 5 An electric tea dryer with capacity of 100–200 kgs of tea/hour costs Rs. 3.5 lakh to Rs. 4.6 lakh. Source: <https://depcenitc.ac.in/electrical/ipg-new/PDF/INDUSTRIAL%20AUDIT/EAM3.pdf>
- 6 Scheme is valid till December 2026. While the average installation per year in Nilgiris is unknown, the average installation rate in districts like Ramanathapuram and Virudhunagar has been 20 pumps per year. A rapid installation will have to be pursued and a realistic target set for coverage under PM KUSUM.
- 7 As per the count of 1,035 commercial accommodations with 5,620 rooms apart from 575 licensed homestays.
- 8 TNAU Agritech Portal
- 9 Horticulture Research Station– Ooty, Tamil Nadu Agricultural University
- 10 Tamil Nadu Agro Climatic Zones, Tamil Nadu Agriculture University.
- 11 District Statistical Handbook Nilgiris District 2021–22
- 12 Department of Economics and Statistics, Government of Tamil Nadu
- 13 Master Plan, Strategy & Action Plan Report, The Nilgiris, July 2023 <https://sd2.tourism.gov.in/DocumentRepoFiles/Master-Plan/MPac06c898-e255-4a17-9d57-8eef46b307cb.pdf>
- 14 Master Plan, Strategy & Action Plan Report, The Nilgiris, July 2023
- 15 Source: District Statistical Handbook Nilgiris District 2022–23
- 16 Statistical Handbook of Tamilnadu 2021–21 <https://des.tn.gov.in/sites/default/files/2023-05/roadandtransport.pdf>
- 17 District Industries Centre, The Nilgiris, Directorate of Industries and Commerce <https://www.dicnilgiris.com/profile.html>
- 18 District Statistical Handbook Nilgiris District 2021–22
- 19 District Statistical Handbook Nilgiris District 2022–23
- 20 Tamil Nadu Wetland Mission
- 21 District Statistical Handbook of The Nilgiri 2021–22
- 22 District Statistical Handbook of The Nilgiri 2021–22
- 23 Tamil Nadu Biodiversity Board <https://tnbb.tn.gov.in/images/pdf/Nilgiris%20Biodiversity.pdf>
- 24 Tamil Nadu Water Supply and Drainage Board <https://www.twadboard.tn.gov.in/content/nilgiri>
- 25 India Climate and Energy Dashboard
- 26 Department of Horticulture and Plantation Crops, Area Coverage final estimates 2021–22 https://tnhorticulture.tn.gov.in/uploads/pdf/AreaCov_21_22.pdf
- 27 Swachh Survekshan 2022 <https://ss2022.sbmurban.org/#/dashboard>
- 28 The Nilgiri District, Government of Tamilnadu
- 29 Swachh Survekshan 2022 <https://ss2022.sbmurban.org/#/dashboard>
- 30 National inventory of Sewage Treatment Plants, March 2021 <https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXM-vMTIyOF8xNjEIMTk2MzlyX2IIZGlhcGhvdG85NTY0LnBkZg==>
- 31 July (normal rainfall of 260 mm) is wettest month followed by August (normal rainfall of about 200 mm)
- 32 Representative Concentration Pathways (RCPs) are concentration pathways used by the IPCC. They are prescribed pathways for greenhouse gas and aerosol concentrations, together with land use change, that are consistent with a set of broad climate outcomes used for climate modelling. The pathways are characterised by the radiative forcing produced by the end of the 21st century. Radiative forcing is the extra heat the lower atmosphere will retain as a result of additional greenhouse gases, measured in Watts per square metre (W/m²). There are four RCPs, RCP2.5 (low pathway where radiative forcing peaks at approximately 3 W m⁻² before 2100), RCP4.5 and RCP6.0 (two intermediate stabilisation pathways in which radiative forcing is stabilised at approximately 4.5 W m⁻² and 6.0 W m⁻² after 2100) and RCP8.5 (high pathway for which radiative forcing reaches greater than 8.5 W m⁻² by 2100).
- 33 The number of heat wave periods not less than 5 days
- 34 Maximum number of consecutive days per year when the daily maximum temperature is above the 90th percentile
- 35 CO₂e are also calculated in terms of Global Warming Potential (GWPs) as reported in the Sixth Assessment Report (AR6) of the IPCC.
- 36 <https://unfccc.int/documents/636235>

- 37 https://unfccc.int/sites/default/files/resource/INDIA_%20BUR-3_20.02.2021_High.pdf
- 38 <https://nilgiris.nic.in/document/district-statistical-handbook-2016-2017/>
- 39 https://censusindia.gov.in/nada/index.php/catalog/43773/download/47479/DH_33_2001_NIL.pdf
- 40 <https://nilgiris.nic.in/document/census-2011-part-a/>
- 41 District Statistical Handbook – 2021-22
- 42 It is worth noting that this number is small, as most agricultural activities in the tea plantations are assisted by manual labour in the district.
- 43 District Statistical Handbook – 2021-22
- 44 <https://indcoserve.com/>
- 45 https://nhm.gov.in/New_Updates_2018/Report_Population_Projection_2019.pdf
- 46 <https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/U8NYUP>
- 47 <https://www.clasp.ngo/research/all/evaluating-appliance-ownership-and-usage-patterns-in-india/>
- 48 <https://energy.prayasapune.org/our-work/research-report/more-with-less>
- 49 <https://dhsprogram.com/pubs/pdf/WP164/WP164.pdf>
- 50 <https://timesofindia.indiatimes.com/city/chennai/families-in-tn-smallest-up-biggest-census/articleshow/36513564.cms>
- 51 Swachh Survekshan, Ministry of Housing and Urban Affairs <https://ss2022.sbmurban.org/#/dashboard>
- 52 https://efaidnbmnnnibpcajpcglclefindmkaj/https://nmcg.nic.in/writereaddata/fileupload/ngtmpr/14_Tamil%20Nadu%20-%20MPR%20May%202025.pdf
- 53 The emission factor used to estimate emissions for activated sludge process (ASP) treatment plants is 0.2 tCO₂e/ML (Singh et al.) and for decentralised wastewater treatment (DEWATs) is 0.133 tCO₂e/ML. Only the commissioned STP of 5.5 MLD has been considered in scenarios and not the STP projects under construction and planning stage due to data gaps.
- 54 Nano fertilisers are nutrients that are encapsulated or coated with nano material in order to enable controlled release and its subsequent slow diffusion into the soil.
- 55 Jagatheesan, Mohanraj & Subramanian, K. & Lakshmanan, A.. (2019). Role of Nano-Fertiliser On Green House Gas Emission In Rice Soil Ecosystem. Madras Agricultural Journal. 106. 10.29321/MAJ.2019.000327.
- 56 United Nations Environment Programme (2024). Promoting a Sustainable Agriculture and Food Sector in India . Nairobi
- 57 <http://nianp.res.in/harit-dhara-tamarin-plus>
- 58 Since the overall geography of Tamil Nadu state is dry and arid and does not reflect the geography of the Nilgiris District, which consists of Tropical evergreen forest, Sholas and grasslands, Savannah woodland etc. that have a higher tree density, a carbon stock of 15 tonnes/hectare was added to the Carbon Stock Density of Tamil Nadu to deduce the Carbon Stock Density of Nilgiris district.
- 59 https://krishi.icar.gov.in/jspui/bitstream/123456789/67642/1/2016_6.22_Potential%20of%20AF_Indian%20Journal%20of%20Agricultural%20Sciences.pdf
- 60 Urban forestry is considered as planning, management and conservation of trees, forests and related vegetation to create or add value to the local community in an urban area
- 61 An urban heat island occurs when a city experiences much warmer temperatures than nearby rural areas.
- 62 Ring Barking is the circumferential removal or injury of the bark of a branch or trunk of a woody plant. Ring barking prevents the tree from sending nutrients from its foliage to its roots, resulting in the death of the tree over time
- 63 Understory is a layer of vegetation beneath the main canopy of a forest.
- 64 <https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1935896>

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