Action Plan for **Decarbonisation Pathways** in **Rajapalayam**

January **2025**

VASUDHA FOUNDATION
Green ways for a good earth!

Tamil Nadu Climate Change Mission

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CHENNAI - 600 009

DATE: 31.01.2025

THANGAM THENARASU
Minister for Finance and
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FOREWORD

Tamil Nadu plays a pivotal role in India's growing economy, contributing approximately 9.21% to the national GDP (2023-24), underscores Tamil Nadu's position as one of India's most industrialized and urbanized states. Urban areas in Tamil Nadu are hubs of economic activity, with significant contributions from sectors like manufacturing, services, and trade. However, climate change poses substantial challenges to various sectors. The key economic sectors also have the potential to adopt low carbon pathways. This highlights the fact that Tamil Nadu, while addressing climate action, has the opportunity to simultaneously enhance climate resilience across its key economic sectors, cities, and districts.

As an endeavour towards this vision, the Government of Tamil Nadu has embarked on an ambitious plan to make Tamil Nadu a low-carbon and climate resilient State under the leadership of Hon'ble Chief Minister. Our goal is to promote climate action at the grassroots level, achieving local resilience by balancing developmental aspirations with environmental conservation.

The Climate Resilient Action Plan (CRAP) with Decarbonisation Pathways for Rajapalayam LPA has been developed keeping these aspects in mind review. It serves as a model to inspire urban communities to actively participate in climate action, contributing to Tamil Nadu's broader objective of climate-resilient growth and achieving Net Zero Target.

I would like to congratulate the Department of Environment & Climate Change, Tamil Nadu Climate Change Mission and Vasudha Foundation for formulating a detailed Decarbonisation Plan for Rajapalayam LPA.

I am confident that this plan will encourage individual and community contributions to climate resilient development at the city level, advancing Tamil Nadu's journey toward its carbon neutrality goal.

(THANGAM THENARASU)

SECRETARIAT
CHENNAI – 600 009
DATE: 31.01.2025

Dr. P. Senthilkumar, IAS
Principal Secretary to the Government,
Environment Climate Change and Forest Department.

FOREWORD

India has been a global leader in driving innovative environmental initiatives. As part of this effort, Tamil Nadu has emerged at the forefront of climate action with visionary programs like the Tamil Nadu Climate Change Mission, Green Tamil Nadu Mission, Wetland Restoration Initiatives, Neithal Restoration Mission, and the Net Zero Emission Roadmap.

Amid increasing climate impacts, it is crucial to localize climate action through a bottom-up approach, starting at the city level. With this vision, the Government of Tamil Nadu is dedicated to fostering inclusive, sustainable, and climate-friendly development. In line with this commitment, the Climate Resilient Action Plan (CRAP) with Decarbonization Pathways for Rajapalayam LPA has been developed by Vasudha Foundation in collaboration with Tamil Nadu Green Climate Company (TNGCC) and Tamil Nadu Climate Change Mission (TNCCM), marking a significant step towards localizing climate action at the city level.

This bottom-up strategy aims to drive low-carbon development in the Rajapalayam LPA while fostering climate-resilient practices through inclusive participation in the planning process. Aligned with the recently adopted Master Plan of the Rajapalayam Local Planning Area, the decarbonization plan reflects a collaborative approach, engaging diverse stakeholders to reduce emissions and build climate resilience.

The plan recommends key strategies such as restoration of Sanjeevi Malai, enhancing urban green spaces, adoption of clean energy sources, sustainable transport, and ensuring the integration of climate resilience and adaptation measures with the goal of achieving low carbon development and sustainable economic development.

I extend my heartfelt appreciation to all the team members of the Department of Environment and Climate Change and Vasudha Foundation, for their dedicated efforts in developing the decarbonisation plan for Rajapalayam LPA.

(P. Senthilkumar)

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Executive Summary

The Rajapalayam LPA has immense potential to become a ‘Model and Showcase’ town and a trendsetter for other towns in India to emulate in being both ‘Climate Smart’ as well as ‘Carbon Neutral’ and with some extra efforts possibly even ‘carbon negative’. Surrounded by the Srivilliputhur tiger sanctuary and having its own iconic Sanjeevi Malai, a hillock that has both historical and religious significance attached to it, Rajapalayam is blessed with lush vegetation that can be further enhanced and strengthened with a fairly high carbon sequestration potential. Furthermore, the area being endowed with close to 42 water bodies covering an area of 19.95 sq. km is also an added advantage to the region.

Further, Rajapalayam is also the textile hub and is the largest consumer of both energy and electricity vis-a-vis the total energy and electricity consumption of the region, accounting to around 70 percent of the electricity and energy consumption.

However, being in close proximity to the districts of Thoothukudi and Tirunelveli, which are the hub for electricity generation from wind, supplying green energy to the Rajapalayam LPA area and the textile industry in particular, by wheeling of electricity from the wind farms is a feasible option and many industries have already opted for this solution.

In the backdrop of the above, this action plan provides a very detailed pathway for decarbonising Rajapalayam intending to make it carbon neutral by 2041, while at the same time, providing a basket of solutions to make the town climate resilient and climate smart.

To put this in perspective, the current greenhouse gas (GHG) emissions of Rajapalayam LPA was approximately 6,86,000 tonnes of CO_2 equivalent, with the majority of its GHG emissions from the electricity consumption, based on a scope two emissions estimation methodology and accounting for approximately 64 percent of the total GHG emissions of the region in the year 2021. The second major GHG emitting sector was the waste sector, which includes solid waste, domestic wastewater and agro waste contributing to approximately 20 percent of the total emissions, followed by the transport and cooking sector. Other sectors or sub-sectors contributing to the GHG emissions include the agriculture sector and primarily emissions from rice cultivation.

Factoring in both economic growth as well as the estimated population growth of Rajapalayam LPA, it is projected that the GHG emissions in the year 2041 are likely to be approximately 7,77,000 tonnes of CO_2 equivalent, assuming a business-as-usual scenario. This projection is primarily based on historical emission trends coupled with the assumption that the ongoing policies and programmes of both the Government of India and the Government of Tamil Nadu, which could potentially contribute to decarbonisation, are successfully implemented.

Keeping this as the baseline scenario, the decarbonisation pathways for Rajapalayam have been developed while factoring in the decarbonisation potentials across various GHG emitting sectors and sub-sectors along with the sequestration potentials, as well as the 2041 masterplan for the Rajapalayam LPA recently adopted by the Rajapalayam Municipality.

The pathways provide three scenarios, namely a moderate scenario, where GHG Emissions are reduced from the possible estimated level of 7,77,000 tonnes of CO_2 equivalent to 3,40,000 tonnes of CO_2 equivalent by 2041, taking into account sequestration potential, which would then mean that Rajapalayam will become net zero by 2050; an aggressive scenario which brings down the emissions to zero by 2041, after factoring in the sequestration potentials and another aggressive scenario with lifestyle and behavioural changes embedded, which could potentially make Rajapalayam carbon negative by 2041 or net zero by 2038.

For each of the scenarios, a detailed list of actions has been provided, which is based on a thorough study of resource potentials and feasibility analysis undertaken while factoring in inputs, perspectives and suggestions from a wide range of stakeholders as well as Rajapalayam community members and elders. While a number of actions/activities are of the nature of infrastructures, some soft actions are also suggested, which are mainly in the nature of awareness generation, capacity building and training and communication and outreach.

The sectors covered in this action plan include the energy and electricity sector, transport, industry, cooking, waste, agriculture, and forestry.

However, for the immediate period, the plan identifies a few priority areas for immediate action and these are as follows:

a. Creating additional sinks through eco-restoration activities in both the Sanjeevi Malai corridor as well as in the urban space.
b. Addressing the issue of growing emissions from the waste sector.
c. Augmenting renewable energy through a combination of ground-mounted solar and solar rooftop in government buildings and high-income consumers, to start off with.
d. Electrifying public transport fleet.

Further, the action plan also has indicative budgetary estimates for each of the sector actions that have been suggested, while also identifying potential programmes/policies/schemes of both the Central Government as well as the Tamil Nadu Government which could be potentially tapped to access incentives, that could be in the nature of both fiscal as well as policy measures. The low-hanging interventions have been exclusively listed along with financial estimation for immediate action as ‘vision 2027’ to kick-start the journey towards carbon neutrality.

Furthermore, the action plan also identifies potential areas where policy modifications may be required particularly to meet the targets set in both the aggressive scenarios as well as the aggressive lifestyle and behavioural change scenario.

A few numbers at a glance on the resource potentials are provided below:

GHG Emissions (in $ktCO_2e$)			
Base year 2021	Baseline scenario 2041	Moderate Scenario 2041	Aggressive Scenario 2041
686	777	340	0

Ground-mounted Solar Potential (MW)	Installed Capacity in Aggressive Scenario (MW)	Estimated Annual Generation Potential (in GWh)	Estimated GHG Reduction (in $ktCO_2e$)	Estimated Percentage of Electricity Demand that Could Be Met
368	300	525	287	67%

Rooftop Solar Potential	Installed Capacity in Aggressive Scenario (MW)	Estimated Annual Generation Potential (in GWh)	Estimated GHG Reduction (in $ktCO_2e$)	Estimated Percentage of Electricity Demand that Could Be Met
Residential: 199 MW	120	200	105	25%
Industries: 82 MW	60	100	52	12.5%
Commercial Sector: 52 MW	20	33	18	2.5%

Biogas Plant Potential (m^3/day)	Installed Capacity in Aggressive Scenario (m^3/day)	Estimated Annual Biogas Production (million m^3)	Estimated GHG Reduction (in $ktCO_2e$)	Estimated Percentage of LPG Cylinder Replacement
3500	1750	0.5	1.2	2.5%

CO_2e Sequestration of the Existing Stock (2021)	CO_2e Sequestration by the Existing Stock till 2041	Restoration Activities and Protection of Sanjeevi Malai	Plantation and Green Spaces (Non-urban Land + Buffer Zones)
645 tCO_2e	22,930 tCO_2e (cumulative) 1,145 tCO_2e (per annum) (removal/ sequestration per year)	Area: 111 ha (40% of the area) 33,115 tCO_2e (cumulative) 1,840 tCO_2e (per annum)	Area for plantation: 1570 ha (50% of total area proposed under aquifer recharge zones + urbanisable area + non-urban area) 7,77,150 tCO_2e (cumulative) 43,175 tCO_2e (per annum)

1. Introduction

India's commitment to achieve net zero carbon emissions by the year 2070 marks a pivotal milestone in the nation's journey towards sustainable development. This ambitious pledge reflects a profound understanding of the urgent need to address climate change and underscores India's determination to play a significant role in the global fight against rising temperatures.

India has taken groundbreaking steps to address climate change as reflected in its Nationally Determined Contributions (NDCs). By 2030, India aims to have 50 percent of its cumulative installed power generation capacity derived from non-fossil fuel sources. As of November 2023, non-fossil fuel-based sources already constitute 43.8 percent of the power mix. Further as on date, solar and wind alone contribute to over 28 percent of India's total power installed capacity with a CAGR of 17 percent between 2015 and 2023.

Beyond the national narrative, the recognition of the critical role played by sub-national entities becomes paramount. As India forges ahead with its national decarbonisation plan, the proactive involvement of states and regions becomes critical for success. This multi-tiered approach is pivotal in realising the broader vision of a carbon neutral and resilient India.

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), intending 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. Rajapalayam has emerged as the first town in the state to declare its aspiration to become carbon neutral by the year 2041. In light of this initiative, Vasudha Foundation, in collaboration with TNGCC and Tapasya Design Studio, has developed a decarbonisation strategy for the Rajapalayam Local Planning Area (LPA).

This comprehensive study delves into the current and historical emissions in the area, assesses the energy mix, projects the future energy trajectory of the region, and presents an all-encompassing decarbonisation plan across various scenarios under consideration.

2. Rajapalayam Local Planning Area -An Introduction

The Rajapalayam Local Planning Area (LPA) is a region distinguished by its dynamic blend of industrial and agricultural activities. This chapter meticulously details the anticipated transformations in demography and land use patterns in Rajapalayam LPA from 2021 to 2041. Additionally, the chapter discusses the economic profile of the LPA, with a focus on the pivotal role of the textile industries and the agriculture sector. Furthermore, the chapter presents the current electricity consumption patterns and the existing GHG emissions inventory, providing a comprehensive baseline for crafting sustainable development strategies and emission reduction interventions for the Rajapalayam LPA.

2.1 Demography and Land Use

The Rajapalayam LPA is located amidst the picturesque Western Ghats, features numerous water bodies and is home to iconic wildlife while boasting a rich cultural heritage. The LPA encompasses Rajapalayam town, 15 adjacent revenue villages, and two Reserved Forests. Currently, the total population of the Rajapalayam LPA is 2.91 lakhs, with approximately 87 thousand households. The population of the region is projected to increase to 4.24 lakhs (~1.34 lakh households) by the year 2041.

The Rajapalayam LPA spans over an area of approximately 149 km^2. The agricultural area accounts for around 66.5 percent of the region with scattered residential and industrial clusters occupying roughly 12 percent of the area. The various water bodies in the LPA region account for 13.4 percent (see Figure 1 for the detailed land use composition).

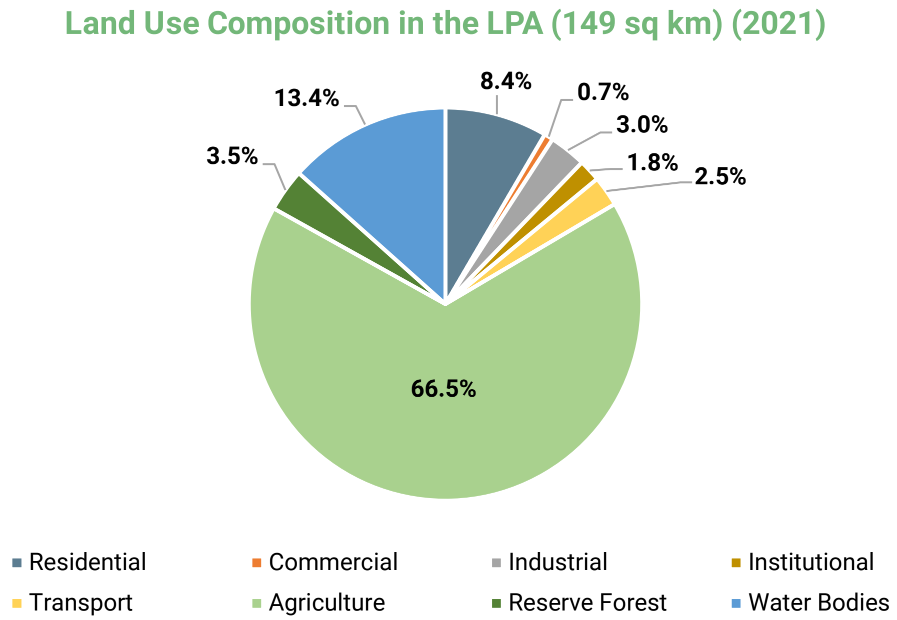


Figure 1: Land Use Composition in the Rajapalayam LPA Area (2021)

Between the years 2021 and 2041, significant demographic and land use transformations are projected for the region. The population is expected to increase by 46 percent, while the number of households could surge by up to 55 percent. In terms of land use, rapid urbanisation is projected with residential areas likely to expand by 75 percent. Industrial zones will experience an even more remarkable growth with a staggering 151 percent increase. Various other land use categories such as institutional areas, road networks, commercial and recreational areas would also see notable growth, nearly 200 percent from 2021 levels. Table 1 summarises the demography, land-use data and projections for the Rajapalayam LPA.

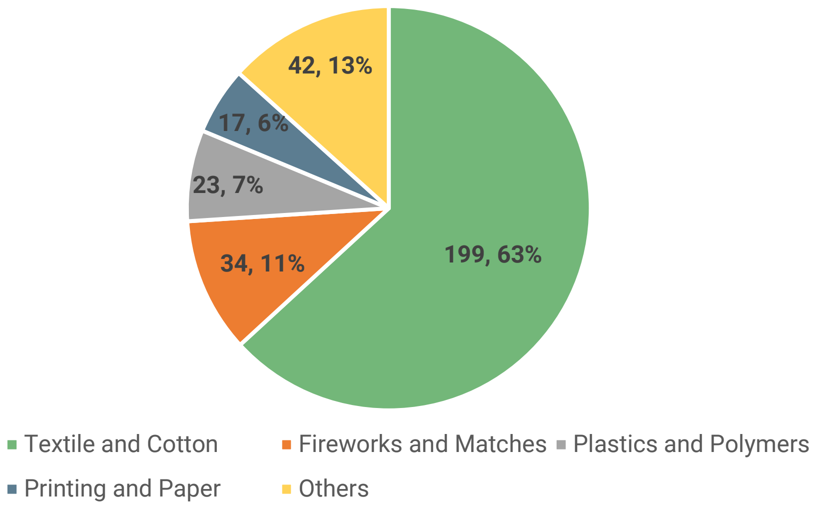
Table 1: Demography, Land-use Data and 2041 Projections for Rajapalayam LPA - at a Glance

Particulars	Year 2021	Year 2041	Percentage Change
Demographic Details			
Population (Municipality)	1,46,731	1,91,120	30%
Population (Non-municipality)	1,43,940	2,33,639	62%
Total Population	2,90,671	4,24,759	46%
No. of Households	86,692	1,34,260	55%
Land-use Details (in sq. km)			
Residential	12.55	21.96	75%
Industrial	4.52	11.33	151%
Reserve Forest	4.59	4.59	0%
Water Bodies	19.95	19.95	0%
Transport	3.72	7.45	100%
Agriculture (incl. ESZ)	99.18	{38.79}	- 30%
Aquifer Recharge Areas	0.00	10.53	
Urbanisable Area	0.00	6.89	
Non-urban area	0.00	13.98	
Others*	4.55	13.59	200%
Total Area	149.06	149.06	-

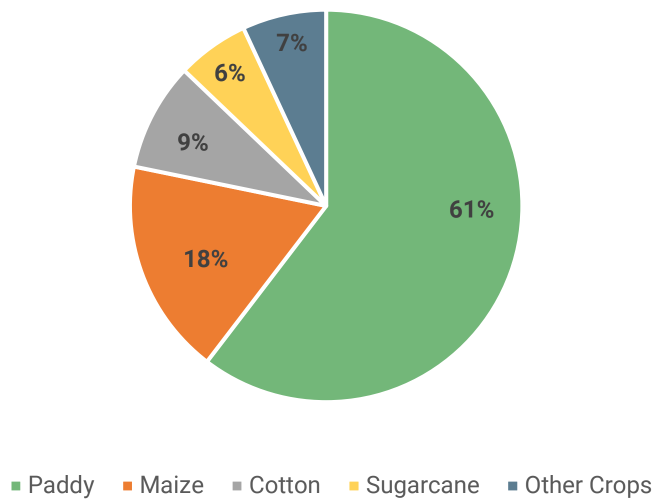
*Others includes institutions, commercial, hills, burial ground, and recreational area

2.2 Economic Profile of the LPA

Rajapalayam LPA is a textile hub, housing numerous spinning mills, ginning mills, power looms, and surgical cotton units. Other major industries include fireworks and match making, plastic and polymer production and paper and printing (see Figure 2). Additionally, agriculture has been the primary economic activity in the region for over a century. This sustained reliance on agriculture can be attributed to the fertile land nourished by water sources originating from the Western Ghats. Furthermore, the presence of rain-fed lands, particularly characterised by black soil, has proven conducive to the cultivation of crops such as paddy, cotton, and maize (see Figure 2), contributing to agriculture's enduring importance.



(a) Sector-wise Industrial Clusters and Number of Industries



(b) Major Crops Share in Net Sown Area (7955 ha)

Figure 2: Sector-wise Industrial Clusters and Major Crops in the LPA Region

Rajapalayam Spinning Industry

Tamil Nadu has the numero-uno status in the textile industry in the country, with 46% of the spinning capacity, 60% of yarn exports, 70% cotton fabric knitting capacity, 20% TUFS investments, and 20% powerloom capacity. Rajapalayam in Tamil Nadu, India, is a significant textile hub with a vast presence of spinning mills contributing to local employment and the broader textile supply chain. These mills, 104 in total, focus on diverse yarn production, emphasising sustainable and organic materials, meeting both domestic and international demands. Rajapalayam's spinning industries have produced around 80 kilo tonnes of yarn in 2022 with an average utilization rate of 86%.

Further, The Tamil Nadu state in its new textile policy 2019 aims to support the industry's growth and sustainability through various incentives and modernisation subsidies. To continue the growth of the spinning sector, the 2% Interest subvention for investments on Technological Upgradation and Modernisation in existing Spinning Mills with a vintage period of minimum 15 years on installed machinery will be provided. Further the Industrial Policy 2014, provides incentives as (i) Back-ended Capital Subsidy ranging from Rs.0.30 crore to Rs.2.25 crore; (ii) Electricity Tax exemption for 2 years to 5 years on power purchased from TANGEDCO or generated or consumed from Captive sources; (iii) 50% exemption from Stamp Duty on lease or sale of land meant for industrial use; (iv) Environmental Protection Infrastructure Subsidy at the rate of 25% of capital cost, with a ceiling of Rs.30 lakh.

Further, a new textile policy is announced to be launched soon that is expected to provide additional support with the announcement of new textile parks in Salem and Virudhunagar district at a cost of INR 880 crore and INR 1800 crore. The land acquisition of 1052 acres has been completed by SIPCOT for the latter.

The Rajapalam spinning industry is also encouraged to pursue Platinum Green Building Ratings (PGVR), signifying a commitment to environmental stewardship and operational excellence. This involves a holistic assessment covering energy performance, water usage, and more. The Textile Policy 2019 also provides Assistance up to 50%, subject to a maximum ceiling of Rs.50,000/- for Energy Audit / Water Audit / Environmental Compliance.

The specific energy consumption of the Rajapalayam spinning industries varies significantly across units indicating room for improvement in energy efficiency. The policy provides assistance up to 20% of cost of equipment required for energy and water conservation, subject to a maximum of Rs.10 lakh.

Apart from spinning units, there are a very few fabric units installed in Rajapalayam which have thermal energy requirements for dyeing and finishing processes, fuelled majorly through fuel wood, predominantly prosopis or through LPG for specific processes like singeing and stentering. With the announcement of new textile parks near the region, more fabric processing industries are expected to come. Since these industries have high thermal energy requirements, it will increase regional carbon footprint significantly given the dependency on coal and other sources. A policy push is required through the introduction of an incentive mechanism to set up new electrified technologies for the new units.

2.3 Electricity Consumption across Sectors

The Rajapalayam LPA has had an annual average electricity consumption of around 550 GWh over the last five years. Industries account for nearly 71 percent of the electricity consumption, primarily by the spinning industries and paper and printing industries. The residential sector accounts for nearly 20 percent of the electricity consumption, while public lighting, commercial sector, and agriculture consume the remaining 10 percent. Table 2 details electricity consumption in Rajapalayam LPA by the type of consumer.

Table 2: Sectoral Electricity Consumption in Rajapalayam LPA from 2018-19 to 2022-23 (in GWh)

Electricity Consumption	2018-2019	2019-2020	2020-2021	2021-2022	2022-23
Domestic (I)	89	91	93	94	97
Commercial(V)	27	27	28	28	29
Industry LT (IIIA, IIIB)	35	35	36	37	38
Public Lighting (IIA) and Others (IIB, IB, IIC, VI)	11	12	12	12	12
HT Industry	383	392	362	409	381
Agriculture (IV)	20	19	15	21	21
Total Consumption (GWh)	565	576	546	601	578

Note: The electricity consumption mentioned in the table above, though disaggregated based on TN tariff consumer categories, were aggregated in feeder meter reading values as per mixed feeder and dedicated feeder (for HT Industries). The consumption values were separated based on consumer load across the segments. Thus, actual data may deviate a few percentage points from reported values.

2.4 Current Emission Inventory

A comprehensive GHG emissions inventory can help identify GHG drivers and identify interventions and strategies for mitigation, thus enabling development of an effective decarbonisation strategy for Rajapalayam LPA.

2.5 Total Greenhouse Gas (GHG) Emissions

Total GHG emissions from the LPA region stand at 686 ktCO_2e in 2021. The energy sector is the predominant source of GHG emissions with 526 ktCO_2e, which represents a substantial 77 percent of the total. This underscores the significant environmental impact associated with energy-related activities, including industries, highlighting the urgent need for sustainable practices and a transition to cleaner energy sources. In comparison, the other sectors such as waste, agriculture, forestry, and other land use contribute only a modest 24 percent, amounting to 160 ktCO_2e, highlighting the relatively modest role it plays in the overall GHG emissions. See Figure 3 for sector-wise GHG emissions in Rajapalayam LPA in 2021.

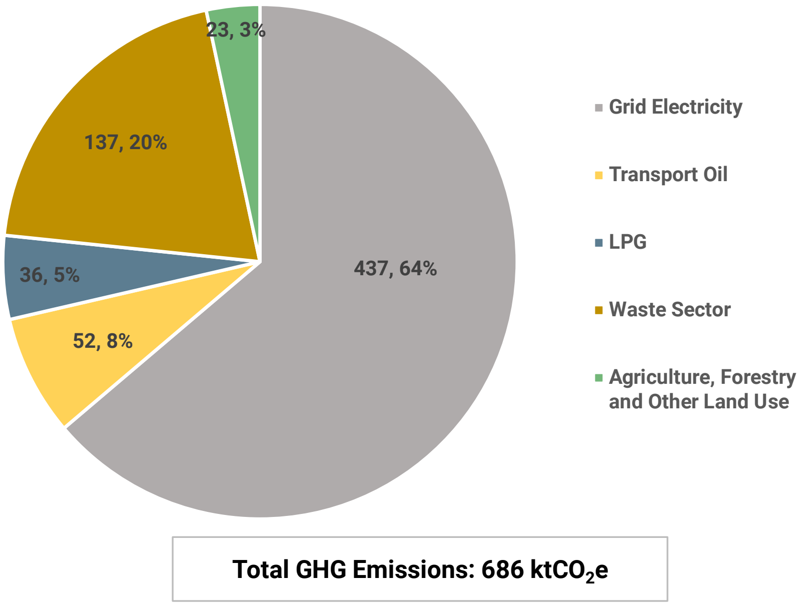


Figure 3: Sectoral Share in Total GHG Emission in the Region (2021)

2.6 Electricity Emission from Energy Sector

GHG emissions resulting from grid electricity consumption across all sectors dominated the total GHG emissions from the energy sector, accounting to 83 percent share, totalling 437 $ktCO_2e$. This was followed by emissions from petrol and diesel consumption in the transport sector with a share of 10 percent, and then the LPG usage in residential and commercial sectors with a share of 7 percent of the total emissions from the energy sector.

Further, from a sectoral perspective, the industrial sector accounted a significant share of 57 percent to the total GHG emissions from the energy sector, equivalent to 297 $ktCO_2e$. This was followed by the residential sector, which emitted 127 $ktCO_2e$ (24 percent of energy sector emissions), transport sector with emissions of 52 $ktCO_2e$ (10 percent of energy sector emissions). The services and agriculture sectors together accounted for 50 $ktCO_2e$ (9 percent of energy sector emissions). Figure 4 shows the sectoral and source-wise GHG emissions in the energy sector in Rajapalayam LPA.

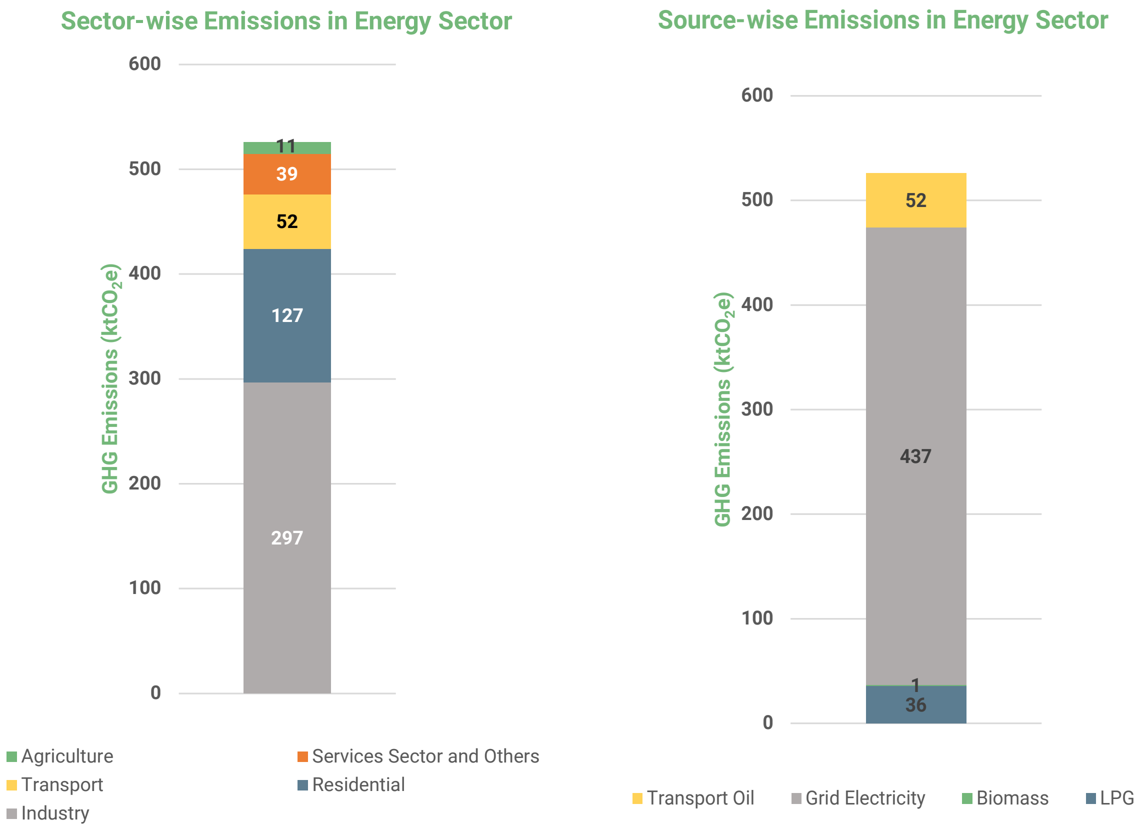


Figure 4: Sector-wise and Source-wise Emission in Energy Sector

2.7 Emissions from Waste, Agriculture, and Livestock Sector

Total GHG emissions from the waste sector is 137 ktCO_2e, which represents approximately 20 percent of the total GHG emissions from the Rajapalayam LPA. Accounting for 61 ktCO_2e, wastewater emissions stand out as the primary contributor. Agriculture waste, cotton and coconut waste in particular, contributes 46 and 15 ktCO_2e, respectively. The domestic solid waste emission accounts for approximately 15 ktCO_2e.

Other sectors or sub-sectors contributing to 23 ktCO_2e of GHG emissions include the agriculture sector, with emissions of 10 ktCO_2e primarily from rice cultivation and agriculture soil while the livestock emits 13 ktCO_2e.

Impact of climate change on Agriculture productivity for Rajapalayam LPA

Rising temperatures, erratic rainfall, and extreme weather events are increasingly impacting Tamil Nadu's agricultural productivity, with adverse effects being felt year after year. Both rainfed food crops and irrigated cash crops are experiencing reduced yields. Virudhunagar, a predominantly agrarian district, has over 66 percent of its population directly or indirectly reliant on agriculture. In Rajapalayam LPA, paddy dominates the agricultural landscape, covering ~2,643 ha. Over 26 percent of the population in Rajapalayam is dependent on agriculture for their livelihoods[1].

The Tamil Nadu State Action Plan on climate change categorises the district of Virudhunagar as having 'Very High' agricultural vulnerability[2]. Between 1990 and 2018 the district has experienced 7 incidences of drought[3]. Additionally, IMD (Pune) also notes that the district is highly vulnerable to droughts[4]. Extreme weather events, projected increase in rainfall and increase in number of rainy days under RCP4.5 and RCP8.5 scenarios (for both southwest monsoon and northeast monsoon) can potentially disrupt sowing & harvesting patterns, impacting agriculture productivity and yields in Rajapalayam. Kamesh (2023)[5] has noted that with changing rainfall patterns, there is a negative association between precipitation intensity and paddy yield in Tamil Nadu.

Disruptions to livelihoods—caused by declining productivity, extreme climate events, erratic rainfall, and shifting sowing patterns—pose a significant threat to the region's agricultural output, jeopardizing both food security and the economic stability of local communities.

1 Master Plan for Rajapalayam LPA 2041

2 https://moef.gov.in/uploads/2017/09/Tamilnadu-Final-report.pdf

3 https://tnsdma.tn.gov.in/img/document/DDMPPDF/Virudhunagar%20Dist%20DDMP-2024.pdf

4 https://imdpune.gov.in/hazardatlas/droughtnew.html

5 Kamesh, T. M. 2023. "Impact of Climate Variables on Paddy Production in Tamil Nadu, India". International Journal of Plant & Soil Science 35 (19):1244-52

3. Projections of Baseline (Reference Scenario) Energy and Emissions till 2041

In this chapter, we delve into the intricacies of the future energy landscape, focusing on both the primary and final energy mix envisioned for the target year 2041. The primary objective of this chapter is to project the trajectory of energy consumption and production in Rajapalayam LPA. This will help decipher the interplay of various energy sources and policies which will shape the future of the region, for example new EV policy transforming the transport sector. The projections of baseline energy and other sectors emissions will help to formulate the three other decarbonisation scenarios prepared in the scope of this study. These scenarios have been discussed in depth in Chapter 4.

Limitations to Projections

The demand projections in energy and other sectors are driven through robust assumptions. Further, the assumptions have been scaled down from the district to LPA level in lieu of data limitations. Some of these limitations are listed below

- Electricity end use consumption data is apportioned based on connected loads due to lack of actual meter data for each of the end uses.
- Limited data on industrial production and capacity in the LPA region.
- Limited information on current renewable energy use, particularly the use of solar rooftop systems in industries, commercial and residential houses.
- Limited data of irrigation and water pumping demand in the LPA including groundwater irrigation and water storage bifurcation.
- Limited transport sector data on vehicle stock, hence vehicle numbers are currently based on traffic based surveys and vehicle ownership profile of the state.

3.1 Energy Sector

3.1.1 Energy Demand Projections till 2041

Demand forecasting at granular level, i.e. end-use, can help develop insights into future growth in appliance penetration, industrial production, vehicular stock etc. At electric utility level, it can support medium to long-term planning of power procurement. This section details the approach and metrics used for estimating the sectoral demand until 2041. Table 3 details the sectors included as well as major metrics and energy uses in the sectors to assess end-use forecasts.

Table 3: Demand Projection Metrics and Inputs across the End-use Sectors

Sector	Demand Projection Approach	Broad Metric Used	Projected Energy Source
Agriculture	Bottom up	Crop production	Electricity
Transport	Bottom up	Ownership per capita	Diesel, Gasoline, Electricity
Residential	Bottom up	Appliance penetration, per Household fuel use	Electricity, LPG, Biomass
Industry	Bottom up (partial)	Specific electricity consumption based on industrial production	Electricity
Services	Bottom up	Energy Performance Index	Electricity, LPG

1. Residential Sector

In 2021, the residential electricity demand stood at 93 GWh, which accounted for one-fifth of the total electricity consumption in the LPA region. This demand arises due to space cooling, appliances and lighting.

Methodology

A detailed stock of appliance penetration is limited in the LPA region, thus demand projection across appliance categories is based upon a set of robust primary as well as secondary data sources. The ownership pattern of major electricity-intensive and non-electricity intensive appliances across municipal and non-municipal demographies is used to estimate the electricity consumption in the residential sector.

From 2015-16 and 2019-21 data from the National Family Health Survey (NFHS) Tamil Nadu report, the household appliance penetration (Table 4) at municipal as well as non-municipal levels were extracted for appliances such as electric fan, refrigerator, air conditioner/cooler and washing machine. Using the growth rate of these appliances between 2016 and 2021, the household appliance penetration was projected till 2041 across respective geographies. For lighting devices such as incandescent bulb, CFL, CFL tube, LED and LED tube, household penetration data was obtained from the India Residential Energy Survey (IRES) of 2020. In the survey, data was not available for Rajapalayam LPA, thus the appliance penetration of nearby districts was assumed to be identical to Rajapalayam. The annual hours of usage and wattage for different appliances were also taken from the IRES survey.

Table 4: Residential Appliance Penetration (Number per Household) in 2021 in Rajapalayam LPA in Municipal and Non-municipal Geography

Category	Municipal	Non-Municipal
Incandescent Bulb	0.50	0.50
CFL	1.60	1.60
LED	1.18	1.18
LED Tube	0.39	0.39
CFL Tube	1.19	1.19
Electric fan	1.17	1.13
Refrigerator	0.51	0.30
Air conditioner/cooler	0.07	0.04
Washing machine	0.12	0.03

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, air conditioners and washing machines were computed from energy efficiency indicators (star labels) of various appliances. The baseline scenario assumes that all devices have baseline efficiency at current levels. Whereas, alternate scenarios with decarbonisation assume a higher level of efficiency with star-rated appliances.

Results

Table 5 shows the residential electricity consumption by appliance category and geography. Overall, electricity consumption is expected to rise by 93-192 GWh across all the scenarios by 2041. With 53 percent appliance usage (refrigerators, washing machines, heater and motors) consumes the majority of electricity consumption, followed by space cooling (fans and air conditioners) at 29 percent and lighting at 15 percent. However, improvements in the energy efficiency of appliances may reduce the overall consumption by 2041 while the electricity demand for cooling will increase significantly, which is discussed in Chapter 5. Similarly, the electricity demand for lighting and other appliances will also rise, although at a moderate pace.

Table 5: Residential Electricity Consumption (GWh) by Category and Geography

Geography	Appliance	Baseline Case Scenario (BCS)	
		Year 2021	Year 2041
Municipal	Lighting	12.95	19.35
	Space Cooling	18.10	34.74
	Appliances	32.21	72.92
Non-Municipal	Lighting	8.60	12.86
	Space Cooling	10.69	19.51
	Appliances	10.44	32.82
Muncipal+Non-Municipal	Total	93.00	192.21

2. Cooking Sector

The cooking sector, often neglected in energy use projections, does consume a substantial portion of residential energy use. Cooking demand is forecasted across both residential as well as commercial segments in the LPA. The projections for cooking demand were based on primary heat requirement and associated energy demand across the LPA. A primary survey was conducted to assess the comprehensive household cooking preferences.[6] Currently, LPG has an 88 percent composite share* in the total household primary energy mix while electricity has a share of only 8 percent.

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. Based on the LPG and firewood consumed in the baseline year, the UE value was calibrated for Rajapalayam LPA, and extrapolated to 2041. The cook stove thermal efficiency was used to estimate the primary energy requirement and forecast the same under different scenarios till 2041. Table 6 shows the current level of LPG cylinder penetration and projected stock in 2021 and 2041.

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6 https://rajapalayamlpa.com/wp-content/uploads/2023/08/230719_Volume_1_lowres.pdf

* composite share is a weighted average share across households which have multiple share of Cooking preferences.

Table 6: Primary Cooking Energy Demand and Electrification Share

Year	Number of LPG Cylinders		Fuel Share in Total Cooking demand		
	Residential	Commercial	LPG	Biomass	Electricity
2021	4,23,872	78,820	88%	4%	8%
2041	6,34,878	102,665			

3. Transport Sector

Transport demand in the LPA region predominantly consists of road transport. To forecast the demand till 2041, a stock model was used, which projects the total vehicle ownership per capita across the light and heavy-duty vehicle segments. To assess this, the historical ownership patterns of vehicle categories over the past decade in Tamil Nadu were investigated. We use the associated datasets from the MORTH yearbook[7] and VAHAN dashboard[8] to calculate the split of gasoline and diesel-based vehicles across all the segments. To assess the demand for public transport plying from and to Rajapalayam LPA, we map the existing intercity and intracity bus routes. This data is sourced through primary data obtained from the bus operator.

Figure 5 shows the ownership of vehicle categories in the baseline case scenario (BCS) from 2021 to 2041. There will be an increase in the private ownership of vehicles, especially 2-wheelers and 4-wheelers. Whereas, transport goods usage vehicles and public transport will achieve peak growth in sales by 2030 and plateau thereafter. This is corroborated by the fact that with higher consumer purchasing power in developing economies, private ownership of vehicles increases. Additionally, scenarios with higher uptake of public transport were also assessed which shall be elaborated in the section on behavioural change.

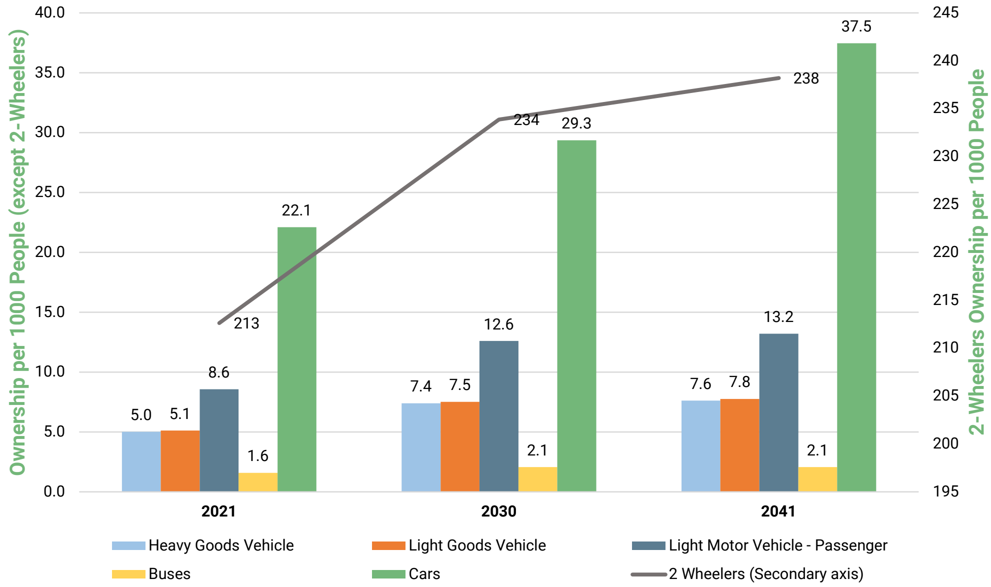


Figure 5: Ownership Per 1000 People for Different Vehicles to 2041

7. https://morth.nic.in/sites/default/files/RTYB_Publication_2019_20%20(1).pdf
8. https://vahan.parivahan.gov.in/vahan4dashboard/

Scenarios were also constructed to estimate the electricity requirement for the road transport sub-sector. These helped present an outlook for vehicle electrification to 2041. These scenarios can be possible trajectories for future demand and not a foreseen predictable future. The BCS, moderate scenario (MES) and aggressive with behavioural change scenario (ABS) rely on the state EV policy targets and national outlook from NITI Aayog. Table 7 shows the scenarios for the share of EV sales in future vehicle registrations. Further, operational characteristics like fuel efficiency, vehicle occupancy, and distance travelled were used to estimate energy use as well as emissions. Additionally, the behavioural shift across the vehicle segments was also estimated; especially, the higher shift of uptake from private to public transport and improved fuel efficiency due to optimal driving behaviour. Other interventions pertaining to transport, like non-motorised transport[9] etc. are given in the detailed matrix of the sectoral interventions. The avoided emissions due to lesser use of private vehicles on account of strengthening the non-motorized transport infrastructure, such as, pedestrian pathways, cycle lanes, etc. and enhancing public transport, would mean behavioural change and hence these possible/probable avoided emissions are accounted in the 'Aggressive with Behavioural Change Scenario' given in the relevant sections of the plan. In our view, these changes could potentially result in Rajapalayam LPA achieving carbon neutrality either by or well before 2038 as given in the 'Aggressive with Behavioural Change Scenario'.

Table 7(a): Fuel Consumption and Share of New Electric Vehicle Sales by 2041 in the BCS

Year	Fuel and Electricity Consumption		Stock of Electric Vehicles (in numbers)		
	Oil (kl)	Electricity (GWh)	Buses	Cars	2 Wheelers
2021	19,776	-	NA		
2041	28,612	34	268	927	68,259
Share of EVs in new vehicle sales ->			30%	10%	60%

Table 7(b): New EV Sales Assumptions in the NITI Aayog Projections for 2030

NITI Aayog Projections	2030
2-Wheeler	80%
3-Wheeler	80%
Public buses	40%
Commercial 4 Wheeler	70%
Private 4-Wheeler	30%

9.These interventions would also have several co-benefits like improved air quality, enhanced safety for women and children, improved health to name a few.

4. Agriculture Sector

Paddy is the major agricultural produce in the Rajapalayam LPA which covers ~64 percent of the total cropped area. Agricultural land use as per the master plan declines to 39 sq.km. in 2041 from 98 sq.km. in 2021, and is marked by a significant drop in paddy cultivation. It is to be noted that data on crop coverage and agricultural output denoted for Rajapalayam block within the LPA is limited. To estimate the electricity consumption from the agriculture sector, water pumping requirement in each cropping season was used as a metric. Based on the agricultural output and crop yield in the past five years, the yield and agricultural output were forecasted till 2041.

Another metric used was the increase in irrigation requirement, since the current share of irrigated land is 64 percent of the sown area. Since irrigation in the LPA depends on the groundwater as well as other sources like tanks and lakes, the total groundwater requirement was not estimated. However, the electricity consumption to water requirement was calculated for the years for which data was available. These metrics were then used to forecast the electricity consumption based on water requirements for future cropping seasons. At present, the LPA has 2,962 agriculture service connections, with a total connected capacity of 15,377 HP. This information suggests an average pump size of ~5 HP per connection, which was used for the estimation. The same uniform pump capacity for irrigation was used to estimate electricity consumption in the agriculture sector for 2041. Table 8 shows the area under major agricultural produce and electricity consumption for 2021 and 2041.

Table 8: Water and Electricity Consumption and Crop Production by 2041 in the BCS and MES

Year	Consumption		Area Under Crop Production (ha)			
	Water (bcm)	Electricity (GWh)	Paddy	Sugarcane	Maize	Other crops
2021	0.72	15.1*	2,643	377	1,603	3,884
2041	1.15	29.5	1,034	247	1,598	1,019

*Actual values

5. Industry Sector

The industrial sector has a significant presence in Rajapalayam LPA. It consumes more than three-quarters of total electricity consumption, of this, heavy industries account for ~90 percent of the total electricity consumption of the sector. These industries include fabric spinning, weaving, plastics, paper etc. Heavy industries consume electricity from both mixed feeders as well as dedicated high-tension (HT) feeder lines (11KV). From the primary data obtained, the specific electricity consumption (kWh per tonne of industrial output) of designated spinning mills was mapped. However, the electricity consumption across other industries remains unknown due to limited data on industrial production. In view of this, the projections for the industrial electricity demand for the HT and low-tension (LT) industries were estimated separately. By tracking specific electricity consumption (SEC) of industries from the data received, the SEC was projected based on the evaluation of energy audit reports and expert opinions. In this manner, the future production of the spinning industries was estimated. For the LT industry, the compounded growth in electricity consumption over the past years was evaluated and the same growth rate was assumed for future years (refer Table 9 for the summary of current consumption and projections).

Table 9: Electricity Consumption from LT and HT Industries in 2021 and 2041.

Year	Specific Electricity Consumption (Spinning) (MWh/Tonne)	Connected Load (MVA)		Electricity Consumption (GWh)	
		LT	HT	LT	HT
2021	7.04	43.52	70.65	35.70	362.20
2041	6.38	58.89	76.00	51.30	399.86

6. Services Sector

The services sector includes commercial buildings, public lighting and other services within the LPA region. To assess the holistic energy usage in the services sector, the stock of commercial buildings, as described in the Rajapalayam Master Plan was analysed. The number of buildings by type of usage (hospitals, hotels, institutions, retail shop, offices, and transit facilities), floor space area (sq. m.) in 2021 as well as total land use under the commercial buildings category were used as metrics.

To project the total commercial floorspace area for 2041, the proposed land use (Master Plan 2041) for commercial buildings was used. A scaling factor was computed based on 2021 land use and applied to the 2041 projection to estimate the built-up area. The Energy Performance Index* (EPI) benchmarks established by the Bureau of Energy Efficiency (BEE) India were used to evaluate the relationship between building area and electricity consumption for each building category. These EPI benchmarks were then utilised to estimate the energy consumption for all building categories in Rajapalayam for the year 2041. Further, based on benchmark indices, annual improvements in Energy Efficiency (EPI) were also assumed.

For public lighting, the street lighting demand for 2041 was determined based on the current stock and type of lighting in the LPA region. This helps understand the scope of energy efficiency by conversion of sodium vapor lamps to LEDs. Table 10 shows the electricity consumption (in MWh) across commercial buildings and public services by 2041.

Table 10: Electricity Consumption (in MWh) in Commercial Buildings and Public Services

Year	Commercial Buildings						Public Services	
	Hospital	Hotels	Institutional	Offices	Retail & Others	Transit	Public Lighting	Other Services
2021	4,410	3,997	3,676	613	10,332	7	4,408	7,534
2041	7,012	14,374	5,845	2,204	37,155	24	6,549	10,450

3.1.2 Results

Aggregate results for total final energy consumption and primary energy supply in the BCS for 2041

a. **Total Final Energy Consumption (TFEC):** TFEC refers to the overall energy consumption by the end users (residential, commercial, transport, industry etc). As shown in Figure 6, industry holds a predominant share, currently contributing to half of the total consumption of electricity. Overall, the growth in total energy consumption is 1.9 percent annually, till 2041, in the BCS. Industry will continue to be the largest energy consumer by 2041. This is followed by transport and residential sectors' energy consumption of 2.2 PJ i.e. 52 percent of the total energy consumption by 2041.

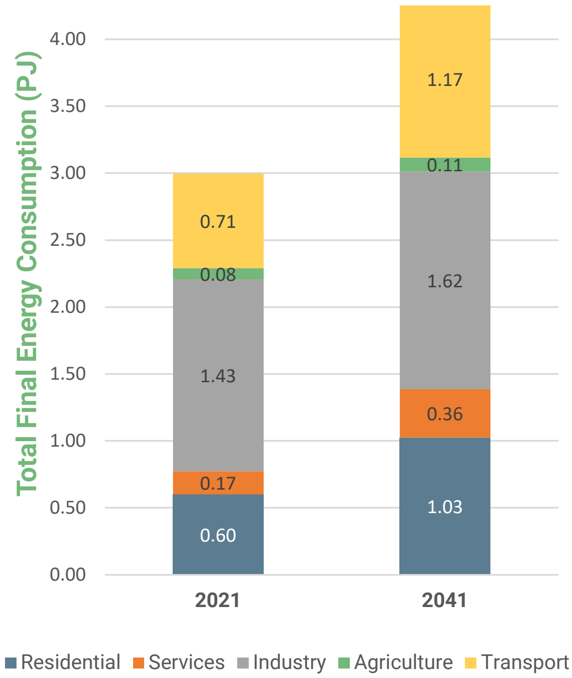


Figure 6: Total Final Energy Consumption by Sector in BCS in 2021 and 2041

b. **Total Primary Energy Supply (TPES):** TPES refers to the primary energy supply at production end as well as imports within the geographical region. Losses including transmission and distribution as well as fuel conversion are included in the primary energy supply. Overall, TPES is expected to increase from 3.5 to 4.85 PJ, growing 1.6 percent annually in the BCS. As depicted in Figure 7, the electricity supply holds a predominant share of more than three-quarters of the total energy supply. This is followed by oil (at 20-22 percent), which has the second highest share. The major source of cooking fuel is LPG which has a significant penetration rate (~86 percent households) and contributes ~11 percent of the energy supply in the BCS.

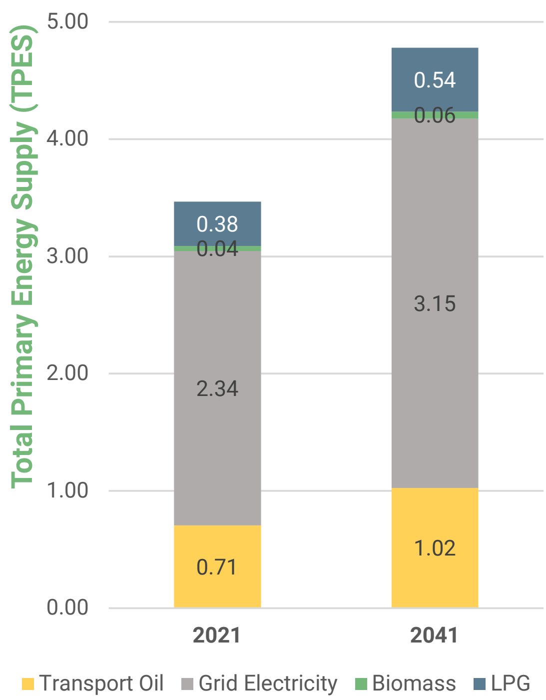


Figure 7: Total Primary Energy Supply by Sector in BCS in 2021 and 2041

3.1.3 Electricity

The substantial share of electricity in the total energy supply of Rajapalayam LPA in 2021 necessitates the assessment of its growth till 2041 and identify the sectors contributing to the change. At present, electricity consumption in the LPA stands at 546 GWh. Industry dominates total consumption at 73 percent of the share which includes both HT and LT industry demand from spinning mills and other industries in the LPA. The residential sector stands second in terms of electricity consumption, contributing a fifth of the total consumption.

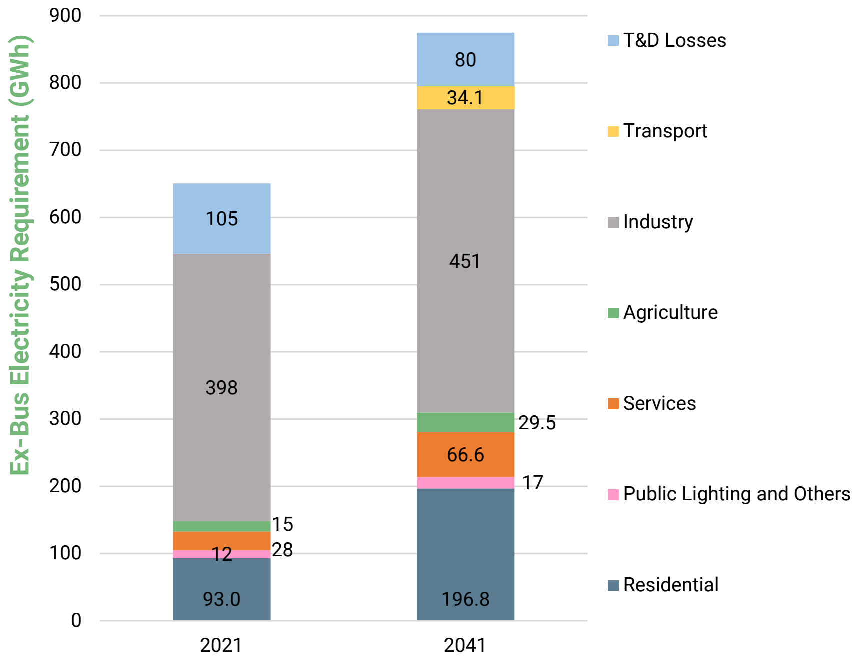


Figure 8: Electricity Demand in 2021 and 2041 in the BCS.

Figure 8 shows the sector-wise electricity demand projections. The LPA's electricity consumption in 2041 is estimated to be around 801 GWh in the BCS, representing a CAGR of 1.8 percent between 2021 and 2041. In terms of ex-bus requirement, this translates to 880 GWh in 2041 from 670 GWh in 2021. The electricity consumption witnesses a moderate growth in 2041, with the sectoral share changing across the different scenarios, but only moderately in the BCS as a result of improvement in system efficiency. Firstly, owing to the rapid energy efficiency interventions, the share of industrial consumption has significantly decreased to 49 percent of the total consumption. Secondly, residential and transport share in electricity consumption rises due to higher appliance penetration and vehicle electrification, respectively. As a consequence, the share of residential consumption increases from 19 percent to 25 percent and transport from 0 to 15 percent throughout the scenarios. Electricity distribution within the region is expected to become more efficient with the reduction in transmission and distribution (T&D) losses reaching 9.5 percent from the existing level of 16 percent; this is consistent with the state's trajectory of reducing T&D losses at a rate of 2.8 percent annually over the past decade. Further, it is to be noted that the grid emission factor decreases from 672 kgCO_2/MWh to 546 kgCO_2/MWh between 2021 and 2041. This is in accordance with the Renewable Purchase Obligation (RPO) trajectory compliance and efforts undertaken by Tamil Nadu state to increase RE penetration.

3.1.4 Emissions from the Energy Sector

As discussed in Chapter 2, ~75 percent of the total GHG emissions across the LPA region in 2021 is attributed to the energy sector alone. Figure 9 represents the growth of GHG emissions from the energy sector in 2021 and 2041 in the BCS. Figure 9(a) and 9(b) depicts the emissions across sector and source, respectively. Note that the emissions remain the same in both the cases, except that the method of representation changes. To estimate the energy sector emissions, activities across the sectors are multiplied by their respective emission factors[10].

Total energy sector emissions are estimated to increase to 626 ktCO_2e from the current level of 525 ktCO_2e, growing at 0.8 percent annually. It is estimated that towards the end of 2041, the industry sector will continue to dominate in emissions rise, accounting for around ~43 percent of the energy related emissions. Whereas, in terms of sources, the electricity sector will continue to be the largest contributor, responsible for three-quarters of the total GHG emissions. Transport oil represents the second largest source of emissions from the road transport sector. Within the economic structure of LPA, there are some sectors where emissions rise and decline are based on activity and further changes in emissions are also influenced by energy efficiency or fuel switching (structural effect). Therefore, it is necessary to determine the causal attribution to each sector, which will be discussed in the following sections.

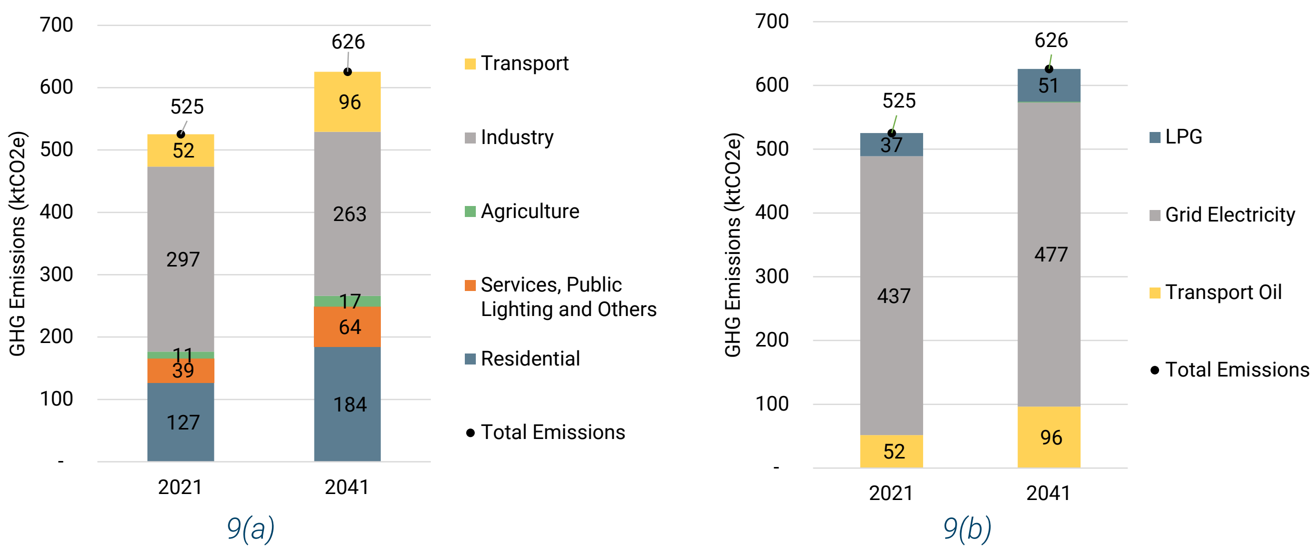


Figure 9: Energy Sector Emissions by Sector and Source in the BCS in 2021 and 2041

3.2 Projection of Other Sectoral Activities till 2041

Currently, the agriculture, forestry, and other land use (AFOLU) and waste sectors are responsible for 23 percent of the gross GHG emissions in the Rajapalayam LPA. Of the 160 ktCO_2e emissions, the waste sector alone contributes a significant 85 percent of the total emission. This is mainly due to solid and domestic wastewater emissions as a result of rise in population and per capita waste generation. It is estimated that by 2041, the AFOLU and waste sectors will experience a marginal decline due to reduction in agricultural activities, as shown in Figure 10 for 2021 and 2041.

10. All Energy sector emission factors noted in Annexure

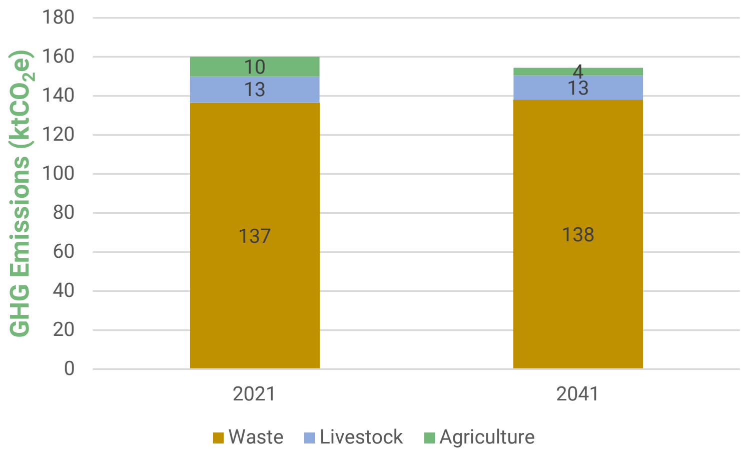


Figure 10: Other Sector Emissions in 2021 and 2041.

3.2.1 Livestock

In 2021, the total livestock emissions in Rajapalayam LPA amounted to 13,235.08 tCO_2e (see Figure 11), with bovine contributing the highest at 10,953.86 tCO_2e, followed by goats (1,779.33 tCO_2e) and sheep (502 tCO_2e). In 2021, the total livestock population[11] in Rajapalayam LPA was 36,197, with cattle being the highest at 14,819, followed by goats [12] at 16,232, sheep at 4,596, and buffalo at 550.

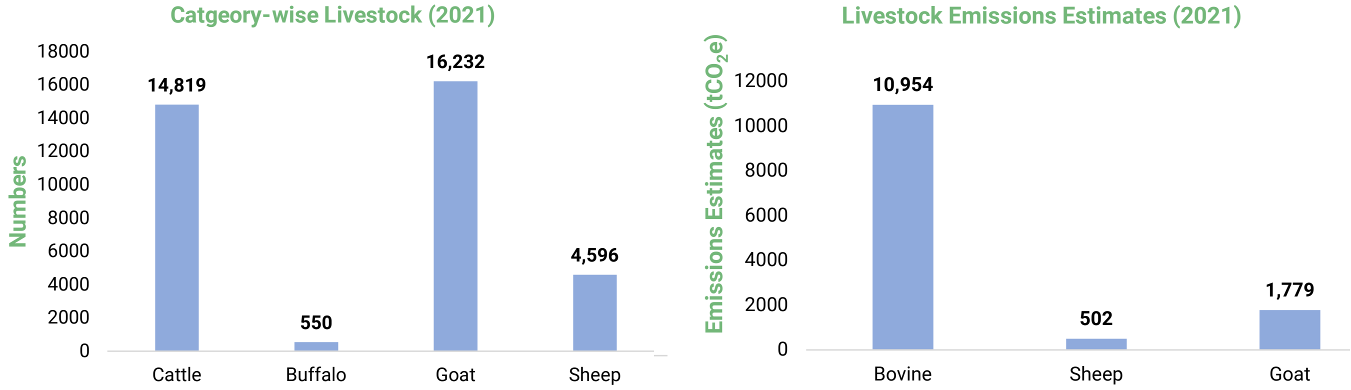


Figure 11: Livestock Population and Emission

11. 2021 population data is based on the CAGR between 20th and 19th livestock census (excluding crossbreed cattle and buffalo).
12. 19th livestock Census (2012) does not provide village wise data for goat population. So goat population was calculated by using the below formula (assuming ratio of livestock category populations in Rajapalayam LPA and Virudhunagar remains more or less the same)Goat population (2012) in LPA=(Goat population in 2019 (LPA)/Goat population of Virudhunagar district (2019))*Goat population of Virudhunagar district (2012)

Methodology to Derive Livestock Population Data of Rajapalayam LPA for 2041

In order to calculate the livestock population of Rajapalayam LPA, data was taken from the 19th and 20th Livestock Census for 16 villages[13] (as per the Master Plan) and Rajapalayam Municipality. The 20th Livestock Census (2019) does not provide segregated data (crossbreed, indigenous, young stock, dairy and adult) for cattle and buffalo; and therefore, the proportion of crossbreed, indigenous, young stock, adult, dairy in the 19th Livestock Census (2012) was applied to the total population of cattle and buffalo in the 20th Livestock Census. Further, population data of indigenous cattle, sheep and goats[14], for future years such as 2025, 2030, 2035 and 2041 were calculated using the CAGR method. To estimate the population of crossbred cattle and buffalo, usually, the CAGR between the last two censuses is taken. However, due to the significant reduction in buffalo and cattle populations between 2012 and 2019, the approach using the CAGR would have meant a significant reduction in the populations of these categories, which is practically impossible. For example, the buffalo population in 2019 was 550 and applying the CAGR method will reduce the population to 33 which is practically incorrect. Hence, the population of crossbred cattle and buffalo were fixed at 13,019 and 550, respectively, till 2041.

Table 11: Livestock Population by 2041

Livestock Category	Population (2019)	Population (2021)	Population (2041)
Cattle (indigenous and crossbred)	14,964	14,819	13,848
Buffalo	550	550	550
Goat and Sheep	22,344	20,828	20,261

Estimated Emissions from Livestock

Emissions from the livestock category were estimated based on 2006 IPCC Guidelines. Tier 2 approaches were used in the emission estimation (refer annexure for details). The country specific emission factors for indigenous cattle, cross-bred cattle and buffalo were taken from India's Second National Communication (NATCOM 2)[15]/India Third Biennial Update Report (BURIII)[16] for indigenous cattle, crossbred cattle and buffalo. For the remaining categories, default emissions factors were applied and referred from 2006 IPCC guidelines.

13. The livestock population data of Appaneri and Kothankulam (RF) villages were not available from 20th livestock Census (2019). As per 19th livestock census (2012) the population data for these two villages were zero, hence it is assumed to be zero in 2019.
14. Goat population for the year 2021, 2025, 2030, 2035 and 2041 were estimated using CAGR with goat population data of Virudhunagar district (applied between 2007 and 2019).
15. MoEFCC. (2012). India Second National Communication to the United Nations Framework Convention on Climate Change. New Delhi: MoEFCC.
16. MoEFCC. (2021). India: Third Biennial Update Report to the United Nations Framework Convention on Climate Change. Ministry of Environment, Forest and Climate Change, Government of India.

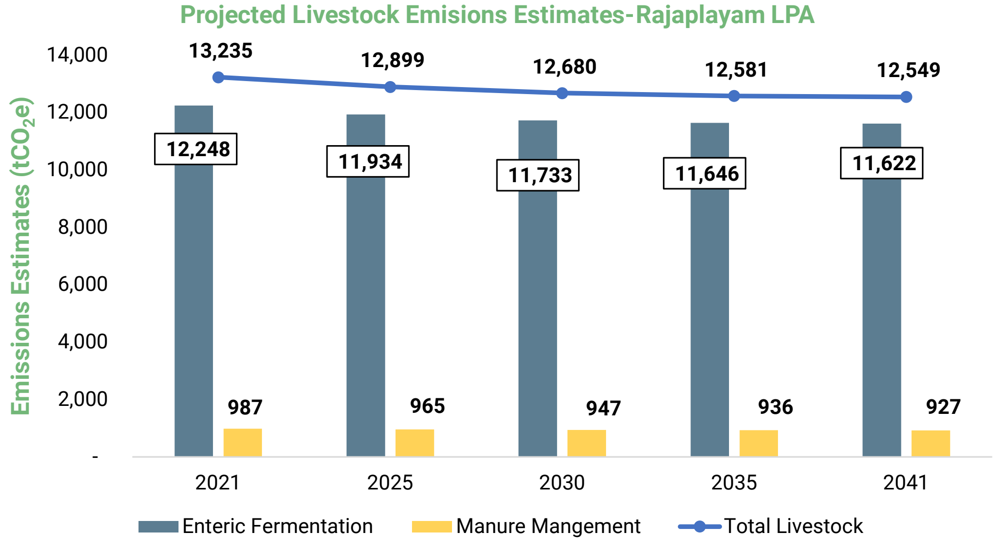


Figure 12: Projected Livestock Emissions Estimates in the BCS

Emissions from livestock in Rajapalayam LPA have been decreasing from 2021 to 2041, and this decline can be attributed to the reduction in the number of livestock in the LPA. The total livestock in Virudhunagar district, however, is increasing. In 2021, livestock emissions totalled 13,235.08 tCO_2e, while in 2041, they are expected to decrease by 5.18 percent to 12,548.88 tCO_2e.

3.2.2 Rice Cultivation

Paddy fields are a significant source of methane emissions in the agriculture sector. Methane emissions arise due to anaerobic decomposition of organic materials in flooded paddy fields. Based on the discussions with the farmers in Rajapalayam LPA, it was established that the water regime followed for rice cultivation is continuous flooding. The area under rice cultivation for the year 2021 is 2,643.14 ha, and the emissions from rice cultivation in that year amounted to 8,991.96 tCO_2e.

While Rajapalayam block level data is given in terms of total cropped area, Rajapalayam LPA has information on the net sown area. Since there is no available data on rice cultivation area in Rajapalayam LPA, the proportion of area under rice within the total cropped area at the block level was used to calculate the area under rice at LPA level for 2021. The projected net sown area for 2041 was calculated using the percentage of net sown area to the total agricultural land at LPA level (of 2021).

To estimate the emissions, the methodology detailed in Gupta et al., (2009) and Pathak et al., (2010) and 2006 IPCC guidelines for national GHG Inventories were followed. Tier 2 approach was used in the emissions estimation. The methane emissions are estimated by multiplying the total paddy rice area under different water management regimes (ha) with corresponding emission factors.

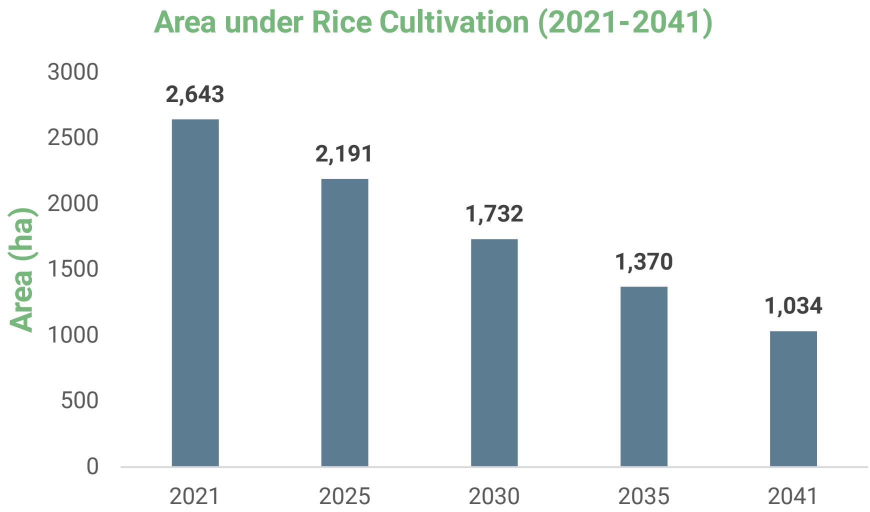


Figure 13: Area under Rice Cultivation in the BCS

As per Rajapalayam LPA Master Plan 2041 the area under agriculture will decline by 2041 with respect to 2021. Therefore, the area under rice cultivation will also decrease. The land use under agriculture (including Eco Sensitive Zone) in 2021 was 99.20 sq.km. The proposed land use under agriculture (including Eco Sensitive Zone) in 2041 is expected to be 38.79 sq.km (60.89 percent decrease).

In 2021 Business as Usual Scenario, where 100 percent of the cultivated area follows a continuously flooded water regime, rice emissions totalled 8,991.96 tCO_2e, while in 2041, they are expected to decrease by 60.89 percent to 3,516.11 tCO_2e.

3.2.3 Solid Waste

When solid waste is disposed of in landfills or dumpsites under anaerobic conditions, methanogenic bacteria break down the waste's degradable organic component, leading to methane (CH_4) emissions. The organic material decomposes slowly, and the CH_4 emissions from a particular quantity of dumped solid waste continue to be released for a few decades.

The municipal solid waste includes waste from residential, commercial and institutional waste, street sweeping, parks and gardens which are either in semi-solid or solid form (this excludes industrial, hazardous, bio-medical and e-waste). The First Order Decay (FOD) model was used in the emission estimation and assumes that carbon present in waste decays gradually over several decades to generate CH_4 emission long after the waste is disposed of, hence, it is necessary to estimate or collect data for 50 years of waste disposal prior to the base year of 2021 (GHGPI Phase 3). The emissions resulting from solid waste disposal in Rajapalayam were assessed from 1951 to 2021, with projections extending till 2041 under different scenarios.

Methodology and Assumptions

Waste generation for the years 2021, 2031, and 2041 was computed using per capita generation of solid waste in the municipal area of Rajapalayam LPA. Dry and wet waste were determined based on a 40 to 60 ratio of the total solid waste generated. The GHG emissions from solid waste were calculated using emission factors for biological waste treatment and untreated solid waste. Currently, 43 percent of the total wet waste generated undergoes processing in

Rajapalayam LPA. In a moderate scenario, it is anticipated that 100 percent treatment of wet waste can be achieved by 2041, while in an aggressive scenario, the target is to treat 80 percent of wet waste by 2031, and then reach 100 percent by 2041.

3.2.4. Agricultural Soil

A portion of nitrogenous fertilisers applied in agricultural soil are lost into the atmosphere through direct emissions of N_2O during nitrification and denitrification. In addition, there are also indirect emissions of N_2O through volatilisation losses, leaching and runoffs.

Data was sourced to obtain the fertiliser consumption data at Rajapalayam LPA, Virudhunagar District, as the granular data at LPA level was absent. The per hectare fertiliser consumption was applied to the net sown area of the district to calculate the total consumption of fertilisers within the LPA. The net sown area for 2041 was projected using the percentage of net sown area to the total agricultural land at LPA level (of 2021).

Emissions from the agriculture soil category were estimated based on 2006 IPCC Guidelines. The country-specific coefficients were taken BUR III . The emissions from agriculture soil in Rajapalayam LPA are expected to decrease from 2021 to 2041, and this decline can be attributed to reduction in agricultural land from 2021 to 2041, as mentioned in the Master Plan. In 2021 BCS, fertiliser emissions aggregated to 1,106.12 tCO_2e, while in 2041, they are expected to decrease by 60.89 percent to 432.52 tCO_2e.

3.2.5 Agricultural Waste

As per the GHG Emission Inventory 2021 for Rajapalayam LPA, agricultural waste from cotton, cotton *kapas*, waste cotton and coconut contribute to the total GHG emissions. According to IPCC methodology agriculture production of these crops does not result in emissions. The net emissions from these crops following the management of their solid waste was 60,686.5 tCO_2e in 2021.

Since, the area under agricultural land is expected to decrease by 60.9 percent in Rajapalayam LPA by 2041, it is assumed that the emissions from cotton, cotton kapas and waste cotton will also decrease by 60.9 percent by 2041. Since coconut is a perennial crop, its emissions are expected to remain the same. Emissions for the years 2025, 2030, and 2035 were computed using the CAGR method.

3.2.6 Wastewater Treatment

Domestic wastewater includes human sewage combined with various domestic sources like drainage from showers, sinks, and washing machines. This category refers to CH_4 and N_2O emissions arising from the processing and release of domestic wastewater. CH_4 emissions result from the treatment of domestic wastewater, either on-site through septic tanks or via connection to a centralised treatment plant through a sewer network, or through an outfall under anaerobic conditions when untreated disposal takes place. The magnitude of CH_4 emissions from wastewater is primarily influenced by factors such as the amount of degradable organic material present in the wastewater, the volume of wastewater generated, and the type of treatment system employed.

Methodology and Assumptions

Wastewater generation in both municipal and non-municipal areas was computed based on population data for the years 2021, 2031, and 2041. The assumed water consumption rates were 135 litres per day for municipal areas and 75 litres per day for non-municipal areas. Considering 80 percent of the total water consumption would result in wastewater generation, GHG emissions were estimated in different scenarios (business as usual - BAU, moderate, and aggressive) using emission factors for both untreated and treated wastewater across various facilities, including Oxidation Pond (OP), Activated Sludge Process (ASP), and Waste Stabilisation Pond (WSP).

Under the moderate and aggressive scenarios, it was assumed that the proposed sewage treatment plants (STPs) with a treatment capacity of 21.85 MLD would be operational by 2031 in the Rajapalayam Master Plan. Subsequently, different treatment capacities were proposed under various scenarios, taking into account the specified capacity.

3.3 Total Emissions

In 2021, the total emissions amounted to 686 ktCO_2e, with significant contributions from the electricity grid and transport while moderate contributions from LPG, waste, and agriculture/land use sectors. Notably, by 2041, the total emissions are expected to increase to 777 ktCO_2e in the BCS, with a growth observed in the transport and electricity grid sectors substantially.

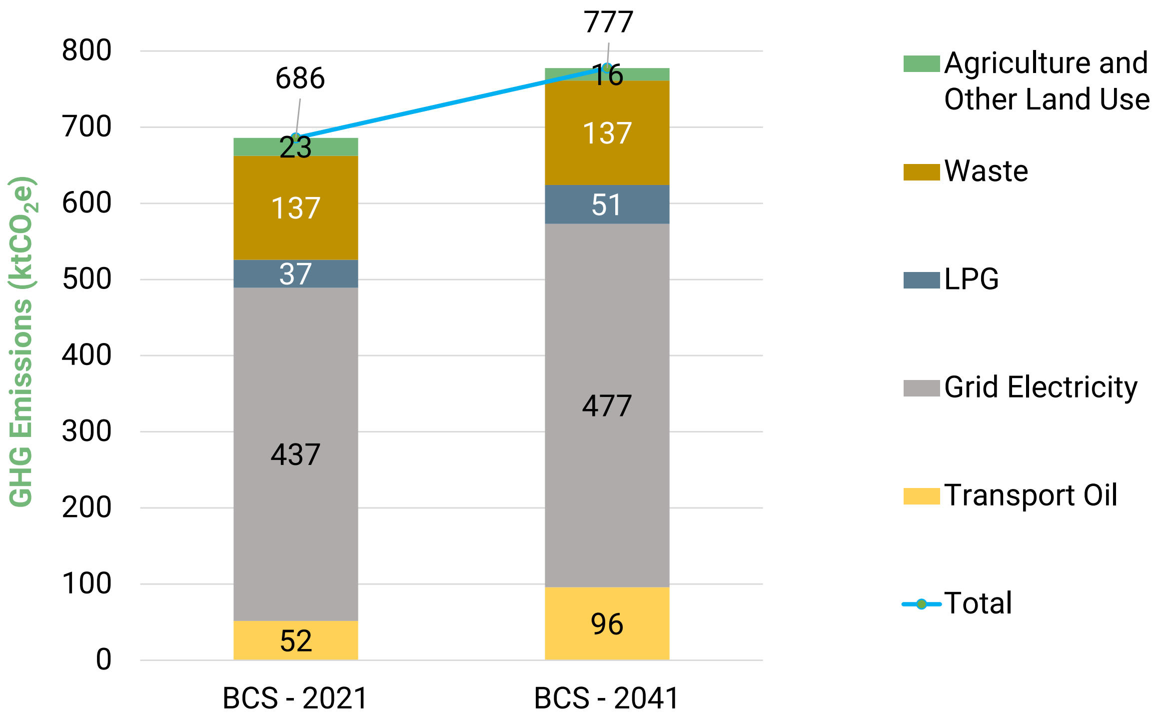


Figure 14: Baseline Emission in 2041

4. Decarbonisation Pathways/Strategies for Rajapalayam LPA

This chapter examines the transformation in the energy and other sectors, embodied in the decarbonisation plan for the LPA. First, it provides the overall approach adopted to devise the decarbonisation plan, including the modelling exercise, stakeholder interaction, and various other detailed assessments of renewable energy potential in the region. This chapter also provides a detailed description of the four overarching scenarios and the various sectoral assumptions that were considered to determine a holistic picture of the emission reduction trajectory in the region. It further discusses the results under the four scenarios and the emission reduction under each from broad contours of emission reduction strategies. Chapter 5 details out each of these contours to provide more actionable targets and interventions.

4.1 Approach Adopted for Devising Decarbonisation Pathway

To develop the decarbonisation plan for the region we have adopted an exhaustive methodology which includes:

a. **Modelling of Energy and Other Systems:** To develop the decarbonisation strategy for Rajapalayam, a bottom-up energy system model was used, which projects energy demand and emissions from 2021 to 2041, 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. It estimates the energy requirements of end use energy demand and associated emissions for various sectors. Among these sectors are residential, services, agriculture, transportation and industry. Apart from these, emissions from other sectoral services were also estimated. These sectors include rice cultivation, fertiliser use, domestic wastewater and domestic solid waste. The potential of carbon sequestration from forestry is estimated within the system boundary. The model takes inputs from the LPA's master plan, Viruddhunagar census data, electricity feeder data, energy audit surveys etc.

b. **Stakeholders Interaction:** Multiple interactions were held with experts from Rajapalayam Mills, Rajapalayam Spinners Forum, District Industries Centre, Tapasya Design Studio, farmers' association, sewage treatment facility, etc. to formalise and create an understanding of various systems in the Rajapalayam LPA.

c. **RE Resource Potential Assessment:** A robust potential assessment exercise was carried out for rooftop solar (residential, commercial, and industrial space), ground-mounted solar, and floating solar PV by processing satellite images, comprehensive site visits and details from the master plan.

4.2 Scenario Framework

The scenarios analysed in this report have been designed in accordance with different operational and technological parameters. The parameters vary depending on system level efficiency, fuel switching and behavioural changes. Subsequently, these parameters were aggregated to define four distinct scenarios, namely baseline, moderate, aggressive and aggressive with behavioural change. Tables 12 shows the disaggregation of scenario assumptions across qualitative as well as quantitative parameters.

Brief Description of Scenarios:

Baseline Scenario (BCS): As discussed in Chapter 3, BCS exhibits energy consumption and supply growth in line with current policies in place and historical trajectory, wherever applicable. In this scenario, improvements in energy efficiency (industry, commercial buildings and residential appliances) are in line with existing levels which follows through 2041, without additional efforts. Similarly, limited fuel switching potential remains in place, which occurs in the electrification of road transport supported by the FAME and state EV scheme. Households and commercial establishments continue to use LPG and biomass for cooking.

Moderate Scenario (MES): MES illustrates the extent to which current national policies and announced targets can achieve emissions abatement, albeit with limited compliance, such as 50 percent non-fossil capacity by 2030. The scenario makes relatively moderate assumptions regarding various sectoral interventions. Specially, energy efficiency, fuel switching, and fleet electrification enable a moderate reduction of ~45-50 percent in the emissions from energy and other sectors. Further, there is a moderate increase in the penetration of efficient appliances to more than 25 percent of the households, such as clean cooking solutions has partially replaced LPG demand with electricity. However, in commercial buildings and heavy industries, the increased compliance to energy efficiency mandates has resulted in reduced electricity demand.

Aggressive Scenario (AES): AES scenario presents an aggressive outlook to decarbonise the region by 2041 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 the overall decarbonisation targets. In this scenario, it is assumed that 90 percent of the total number of vehicles plying on the road are electric, thus reducing the demand for transport oil and associated emissions significantly; whereas approximately 80 percent of households are assumed to switch to clean cooking solutions. Similarly, in this scenario energy efficiency will play a substantial role in avoiding demand, for example, residential consumers switch to energy-efficient appliances, and industries comply with the energy efficiency measures mentioned in the energy audit report.

Aggressive with Behavioural Change Scenario (ABS): This scenario includes some of the behavioural intervention over and above the aggressive scenario. Avoided demand as a result of behavioural changes along with the ambitions set under AES ensure deeper reduction in system level emissions. Therefore, ABS is the most ideal representation of the energy system in the LPA region by 2041 or well before 2041. Notably, these behavioural changes that include improvement in vehicle fuel efficiency due to optimal driving behaviour, switching to public transit, cycling and pedestrian zones and additional efficiency gains from space cooling, such as setting the AC temperature to 26°C, which results in overall avoided demand.

Table 12. Scenario Framework and Associated Metrics Considered

Scenario	Electricity Demand (GWh)	Total Average EV Adoption in new sales	Cooking Fuel Switching	Avg Fuel Efficiency and Improvement	Public Mobility Penetration	5 star Appliance ownership	Industrial Electricity Intensity	Area Under paddy cultivation	Fertilizer Replacement with Compost	Additional Land under Sequestration (Hectares)*
Baseline Scenario	794	NA	NA	Bikes -42 Km/L Cars - 14 Km/L	2.4 vehicles/ 1000 people	NA	7.05 MWh/ Tonne	99 Sq km	950 Tonnes	-
Moderate Scenario	-	70%	44%	-	-	45%	-2% CGR	-30%	-50%	82
Aggressive Scenario	-	85%	76%	-	-	80%	-2.5% CGR	-60%	-100%	
Aggressive Scenario with behavioural change	-	85%	76%	Bikes - 0.5% CGR Cars - 0.5% CGR	2.6 vehicles/ 1000 people	80%	-2.5% CGR	-60%	-100%	

* As per the Rajapalayam Master Plan-2041

CGR - Compounded Growth Rate

4.3 Scenario Results and Emissions Abatement by Implementing Major Interventions

The section outlines the results on energy use, non-energy uses and associated emissions till 2041 based on the overarching scenario framework discussed in the previous subsections.

4.3.1 Change in Total Energy Supply (TES) and Total Final Energy Consumption (TFEC)

In this section, we further delve into the growth in TES across the scenarios and the underlying sectors in which the overall growth or decline arises. The TES for each scenario is depicted in Figure 15(a). Overall, the TES is projected to increase from 3.5 PJ in 2021 to an order of 3.6 to 4.8 PJ in 2041. There is an overall increase in the share of electricity in TES, which may rise from 67 percent in 2031 to 72-78 percent in 2041, as the share of electrification in the road transport and residential sector increases. However, the overall demand for oil and LPG is expected to decline across all the scenarios. With increased fuel switching in transport and residential segments, the quantum of electricity supply is likely to increase from 2.4 to 3.2 PJ in 2041, representing an annual growth of nearly 1.6 percent. It is, therefore, imperative to expedite the development of green energy sources in the LPA region.

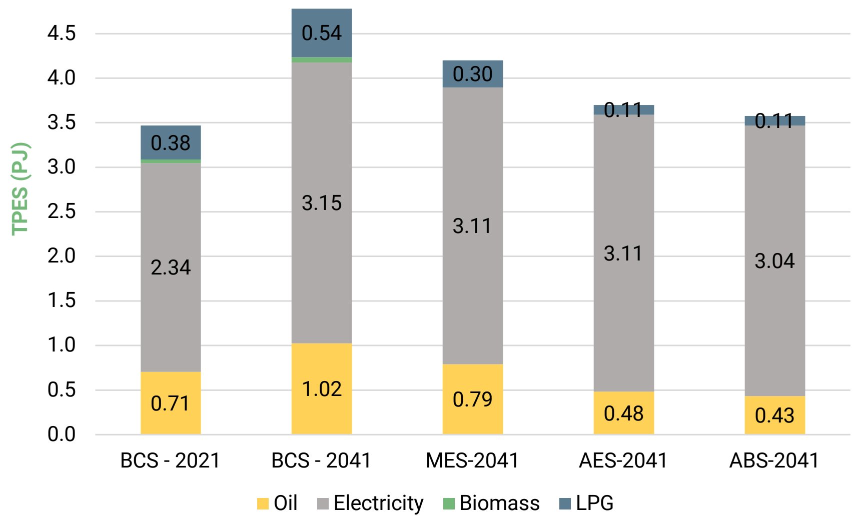
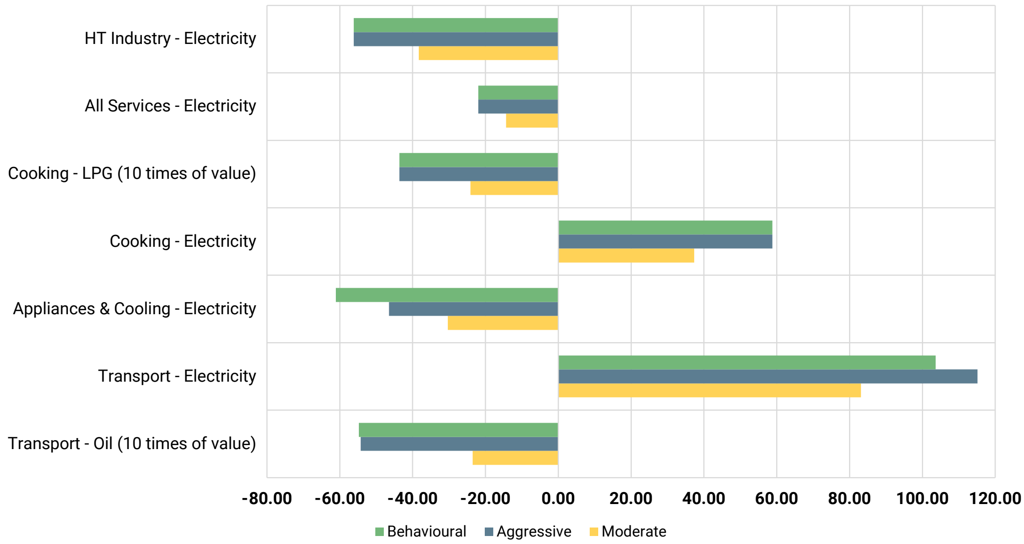


Figure 15(a): Total Primary Energy Supply across the Scenarios

Based on the earlier conclusion, the sources of energy supply change drastically across the scenarios; however, it is important to identify which sub-sectors within the economy contribute to the overall change demand by 2041. Figure 15(b) shows the change in TFEC disaggregated by sectors and their major source of energy supply. Both sides of the x-axis represent net change in TFEC as compared to the BCS in 2041. As seen in the Figure, increase in electricity consumption in road transport and residential cooking contributes to the majority of net positive change in consumption. In contrast, this increased demand replaces oil and LPG demand which observes a reduction by 37-69 GJ and 24-44 GJ, respectively. Energy efficiency will play a key role in reduction of electricity consumption in residential appliances, heavy industries and commercial buildings. Overall, electricity consumption is expected to witness a net reduction of 83-141 GWh by 2041.



(All Values in GWh except oil and LPG in X10 TJ, Transport-Oil and Cooking-LPG are denoted in X10 Values) (Values in positive shows increase in energy consumption and vice versa)

Figure 15(b): Change in TFEC as Compared to BCS-2041

4.3.2 Electricity Consumption

Under the BCS scenario, there is a substantial increase in total electricity consumption from 546 GWh in 2021 to 794.04 GWh in 2041, representing a notable rise of approximately 50 percent. The growth is primarily attributed to significant increases in the industry and transport sectors (EV demand), which have experienced a surge from 398 GWh to 451 GWh and from 0 GWh to 34 GWh, respectively. The residential sector will also witness significant electricity growth from 93 GWh to 195.7 GWh in 2041 due to increase in population and economic status of the region. The overall trend indicates a considerable escalation in electricity demand, reflecting the expanding energy needs across various sectors in the given scenarios.

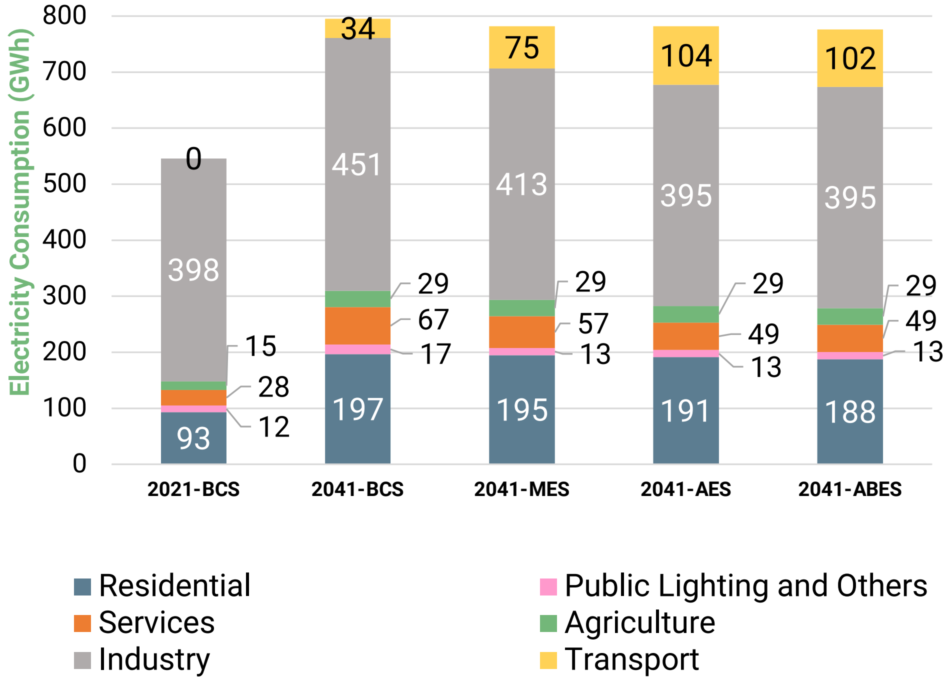


Figure 16: Electricity Consumption across the Scenarios in 2021 and 2041

Emissions Reduction across Scenarios

This section outlines the emission trajectory Across the scenarios discussed. The emissions reduction trajectory includes a strategic approach to mitigate GHG emissions. Further, the priority of these mitigation actions aligns with both abatement potential as well as medium to long term economic viability. Various opportunities for macro level mitigation measures including energy efficiency, variable renewable energy (VRE i.e. solar and wind) integration and other measures are discussed before elaborating them in detail in the next section. In the BCS, emissions will continue to reach peak intensity by 2041 growing at a rate of 0.7 percent annually. Emissions peak in the MES around 2030, before it starts tapering off, although only a moderate reduction in the emissions is observed by 2041, a reduction of 49 percent as compared to BCS. In the AES, emissions curve bends from 2030, reaching net zero by 2041. However, with additional mitigation measures driven by behavioural change zero emissions will be achieved by 2037-38, well before 2041.

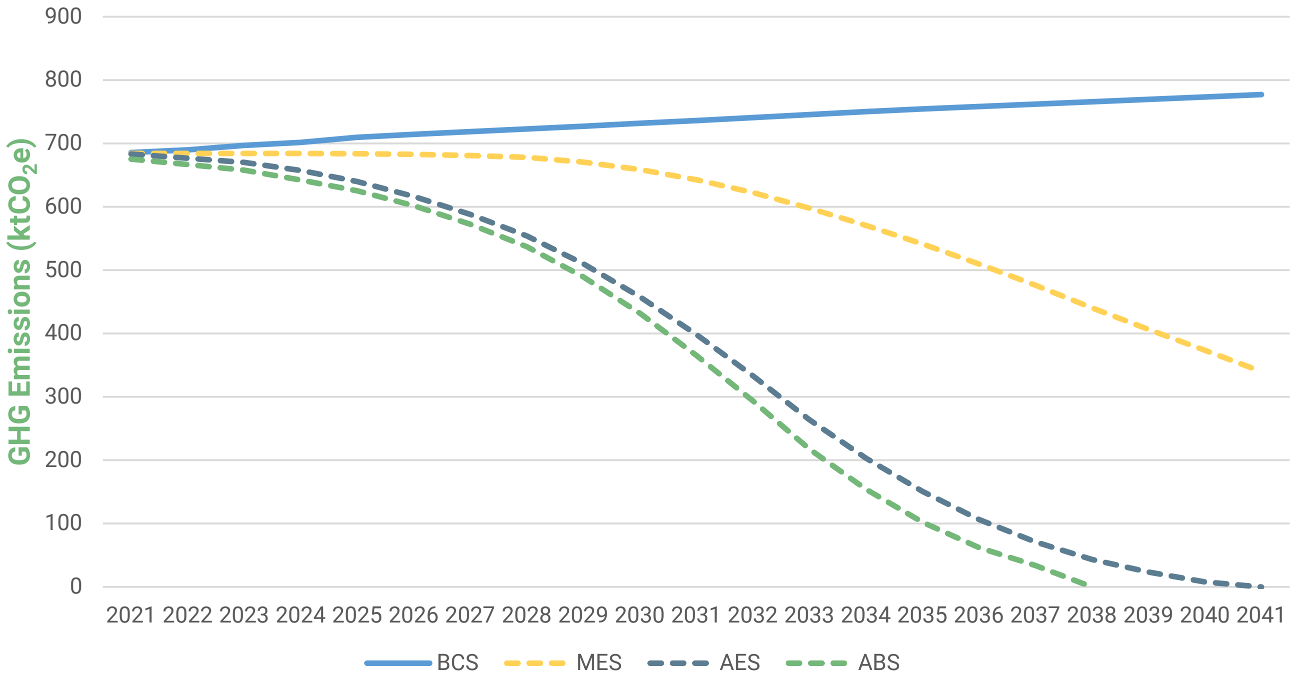


Figure 17: Emission Trajectory Across Scenarios

i. Mitigation Trajectory in the MES

The mitigation measures under the MES are shown in Figure 18. Carbon sequestration focuses on capturing and storing carbon to offset emissions. Livestock and land management aims to reduce methane emissions and promote carbon sequestration in soil. Energy efficiency focuses on enhancing the efficiency of energy usage across sectors, to curb emissions through technological advancements. Greening electricity involves transitioning to renewable energy sources, minimising carbon-intensive power generation. Finally, fuel switching entails shifting from fossil fuels to cleaner alternatives, contributing to a reduction in emissions majorly across industries and transport. Together it is observed that renewable energy generation can support 48 percent of the abatement potential by 2041 whereas, energy efficiency and other non-energy sector measures enable 71 $ktCO_2e$, i.e. 11 percent of the abatement potential.

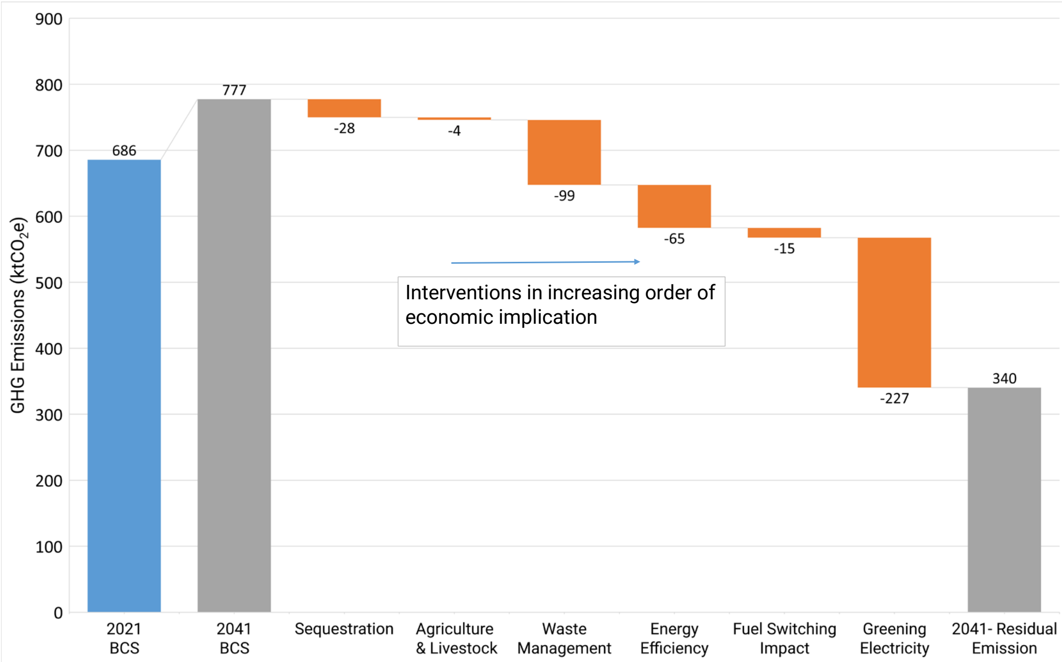


Figure 18: Mitigation Trajectory in MES

ii. Mitigation Trajectory in the AES and ABS

In AES, GHG emission reduces by 65 percent solely by the integration of renewable energy, primarily due to the installation of ground-mounted solar plant, installation of rooftop solar plants on residences and industries. Besides the emissions mitigated through greening electricity, fuel switching and energy efficiency, behavioural change across the sectors can also result in avoided demand in the AES. As shown in Figure 19, in addition to the emissions abatement in AES, 36 ktCO$_2$e of avoided demand due to behavioural change is anticipated to contribute to carbon neutrality by 2041.

Greening the electricity is expected to contribute to the majority reduction in GHG emissions. Energy efficiency and fuel switching can also lead to substantial electricity consumption reduction in AES, contributing 97 ktCO$_2$e of GHG emissions reduction. Whereas, sequestration and other sectors (majorly waste) can reduce the overall GHG emissions by 175 ktCO$_2$e.

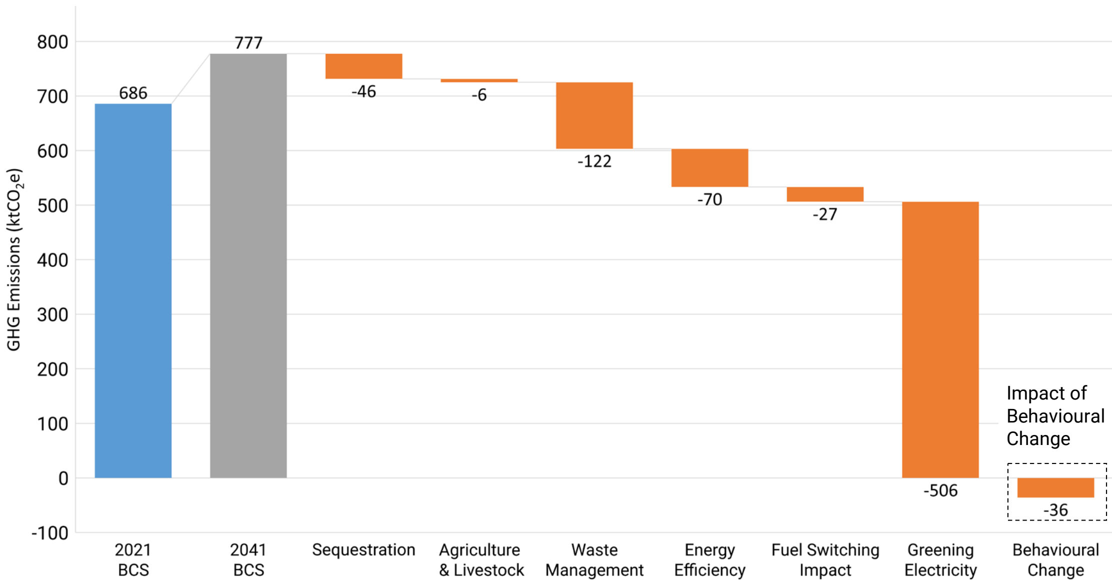


Figure 19: Mitigation Trajectory in AES and ABS

5. Interventions for Decarbonisation Strategy in Rajapalayam LPA

Chapter 4 discussed the broad level mitigation potential across the scenarios from 2021 to 2041 to reach carbon neutrality in the region. This chapter focuses on interventions across the spectrum of mitigation measures in detail and the level of emissions abatement potential by the years 2030 and 2041. The strategies range from the energy sector like greening the electricity, sustainable transportation, energy efficiency, fuel switching, waste management, sustainable agriculture, land sequestration etc.

5.1 Adoption of Renewable Energy

5.1.1 Solarising Rooftops Within the LPA

Currently, there is a moderate penetration of solar rooftops within the spinning mills in the LPA region and limited penetration in the commercial and residential segment. Predominantly, solar energy is consumed through open access or captive routes located at a distant from the industry. Based on the geospatial analysis of rooftop solar potential in the LPA region, there is a wide scope of solar rooftop to be harnessed in the industry sector ranging between 82-96 MW, out of which only ~7 percent has been harnessed till date.

Further, residential and commercial segments also have a significant potential for rooftop solar installation. Based on the geospatial assessment conducted, the residential sector has a rooftop potential of 198-232 MW while within the commercial sector, 52-61 MW capacity of rooftop solar can be integrated into the electricity grid. Table 13 shows a trajectory under ABS and MES till 2041 through which industries, residential and commercial sectors within the LPA can shift to rooftop solar along with their abatement potential. Despite the rooftop solar capacity being lower than the potential, ABS scenario enables a complete decarbonisation of the residential sector even with higher penetration of residential appliances.

Table 13: Rooftop Solar Penetration and Emissions Abatement Potential Under Various Scenarios

Year	Sector	Moderate Scenario (MES)		Aggressive Scenario (AES)	
		Solar Rooftop Capacity (MW)	Emissions abated ($ktCO_2e$)	Solar Rooftop Capacity (MW)	Emissions abated ($ktCO_2e$)
2030	Industry	25	15	33	20
2041		48	26	60	53
2030	Residential	59	57	93	90
2041		79	68	120	105
2030	Commercial	15	15	20	18
2041		21	18	20	18

5.1.2 Ground-mounted Solar PV Capacity in the LPA

Ground-mounted solar PV has abundant potential within the LPA boundary. Based on Vasudha Foundation's geospatial analysis, multiple sites under the fallow land category indicated in the Master Plan-2041 have been identified. These sites cover around 24 centers with an estimated area of 1472 acres in the LPA. Thus, ground-mounted solar PV has an aggregate potential of 368 MW; in AES we considered it as 300 MW (80% of potential) which has a GHG abatement potential of 287 ktCO_2e in 2041 (See Table 14).

Table 14: Ground-mounted Solar PV Capacity and Abatement Potential by 2041

Scenario	Parameter	2030	2041
MES	Solar Capacity (MW)	92	184
	Total Emissions Abated (ktCO_2e)	99	176
AES	Solar Capacity (MW)	184	300
	Total Emissions Abated (ktCO_2e)	197	287

5.1.3 Solar Pumps in Agriculture Sector

Based on the primary data received, currently, 18 solar pumps are installed in the LPA region for agricultural pumping. As discussed in previous sections, there are close to 3000 metered pump connections of average 5 hp pump capacity. Despite the slowdown in agricultural activities by 2041, moderately higher irrigation is anticipated due to the expected intermittency in rainfall and declining water table (resulting in increased pumping capacity). It is thus estimated that close to 1000 new solar grid connected pumps can be electrified which has an abatement potential of 3.64 ktCO_2e by 2041.

5.1.4 Power Procurement by the Industries

Currently the industry sector consumes a major chunk of electricity demand in the LPA at 398 GWh and is expected to rise to ~451 GWh (connected load of 135 MVA) constituting 58 percent of the total electricity consumption by 2041. Further, as per the primary data received for 13 spinning mills, presently ~65 percent of major spinning units use captive power (this includes LT/MT/ST contracts) and have an average RE share of 52 percent in their overall consumption. Only a few industries currently source power through green open access or captive routes. A higher share of solar and wind would ensure faster abatement in emissions across the region. Thus, a total of 350 MW solar or wind-based capacity is required to shift to green electricity sources by the HT and LT industries. Such capacity could be tied up through green open access routes or captive routes within or outside the LPA boundary. With ~300 MW anticipated solar capacity addition within the LPA region (as per the assessed technical potential), industries would need to contract additional ~50 MW of solar based capacity through open access route, which can abate 38 ktCO_2e emissions by 2041.

5.1.5 Floating Solar PV Capacity in the LPA (Optional)

Rajapalayam LPA constitutes a total of 42 water bodies that are non-perennial in nature. The cumulative surface area of these water bodies amounts to 3,252 acres. At 20-30 percent water body coverage by area, around 263 MW-394 MW potential is envisaged with widespread implementation of floating solar PV. Keeping the non-perennial nature of water in water bodies,

the need for flexible ground mounts is envisaged and detailed in a separate report.
Though all the scenarios studied in this report do not consider the floating solar potential as the mitigation intervention, it could be an optional and potential source for carbon abatement in future.

5.2 Electrification of Vehicle Fleet

The sector has a moderate GHG emission footprint contributing to ~15 percent of the total emissions in the LPA. However, the transport sector is majorly dependent on oil which in the future is expected to increase given a higher share of private ownership of vehicles. Thus, decarbonisation of the road transport sector is expected to show co-benefits of sectoral decarbonisation as well as economic savings in terms of fuel expenditure. Further, the pace of road transport electrification would depend on penetration between the public and private sector. Thus, the interventions listed below show a trajectory separately and their mitigation potential.

5.2.1 Electrification of 2Ws and 4Ws

Private ownership of vehicles is especially very high not only in Rajapalayam LPA, but in Tamil Nadu as well, which exhibits one of the highest ownership rates in the country. Thus, it is imperative to replace the existing fleet of privately owned ICE vehicles with EV. In the MES, a substantial reduction in oil demand in the range of 1.2-4.3 million litre (ML) can be observed while in the AES, 2.3-6.1 ML of oil is replaced with electricity as the source. Further, by 2041, the mitigation potential is anticipated to reach 14-20 ktCO_2e.

Further, the avoided emissions of about 3-6 ktCO_2e due to lesser use of private vehicles on account of strengthening the non-motorised transport (NMT) infrastructure, such as, pedestrian pathways, cycle lanes, etc. and enhancing public transport, would mean behavioural change and hence these possible/probable avoided emissions are accounted in the 'Aggressive with Behavioural Change Scenarios' given in the relevant sections of the plan. In our view, these changes could potentially result in Rajapalayam LPA achieving carbon neutrality either by or well before 2038 as given in the 'Aggressive with Behavioural Change Scenarios'.

It is thus recommended that:

- Awareness programs need to be organised to make consumers aware of the economic incentives and environmental benefits of owning electric vehicles. This could be initiated with local schools, community centers, and social organisations etc.
- Community carpooling and ride-sharing programs can be initiated for residents with similar commuting routes and EVs could further add to the mitigation potential of this initiative.

5.2.2 Electrification of Public Transit

Rajapalayam LPA currently serves the public with intra as well as intercity transit within and beyond the LPA boundary. However, the source of fuel predominantly remains oil consumption. At present, there are approximately 241 buses in the fleet, with intracity and intercity buses having near similar shares. With the projected growth in population and rapid urbanisation in the region, it is anticipated that by 2041, 450-480 new buses will be inducted into the fleet of Rajapalayam LPA. These could be a combination of intra city as well as intercity. Further, light passenger vehicles have a scope to deliver last mile connectivity. Thus, by 2041, the mitigation potential is expected to be 5 ktCO_2e for both the categories. Below are some initiatives which can further abate GHG emissions:

- Develop sustainable infrastructure: Develop a network of charging stations strategically located within the LPA. This will encourage the adoption of electric vehicles and address concerns related to range anxiety.
- Enhance last-mile connectivity: Promoting the use of light passenger vehicles and non-motorised transport modes.
- Additional intervention with an introduction of 70 additional intra city buses can lead to 0.7 $ktCO_2e$ emission abatement due to shift to public transport.
- In addition to this, improvement in vehicle efficiency (0.5 percent) due to driving behaviour gives 9 $ktCO_2e$ additional savings.

Table 15: New EV Sales by 2041 and GHG Mitigation Potential

Vehicle Category	New EV Sales till 2041		GHG Mitigation Potential ($ktCO_2e$)
	EVs in New Sales	Number of Vehicles	
2 Wheeler	80%	65,000	17.93
4 Wheeler	70%	4,500	1.98
E- buses	40%	450	4.13
3 Wheeler	80%	2,500	6.56
Trucks	5%	100	1.09

5.3.1 Industrial Energy Efficiency by Mandatory Energy Audits

Industrial energy efficiency interventions will ensure the highest GHG emissions reduction in the LPA. These interventions range from energy intensive processes to moderate processes in the spinning mills. Based on past energy audit reports, even low-cost energy savings measures in the spinning mills including energy efficient fans, Variable Frequency Drive (VFD) controls, pressure optimisation, air leak arresters can lead to substantial savings. It is anticipated that low-cost interventions could lead to 6.5-7 percent improvement in specific electricity consumption and 11 percent in medium-cost interventions. Table 16 shows the improvement in electricity savings and emissions abated across the scenarios.

Table 16: Emissions Abated Due to Low-cost Energy Efficient Measures in Spinning Mills

Scenario	Electricity Savings (GWh)		GHG Emissions Abated ($ktCO_2e$)	
	2030	2041	2030	2041
MES	17.1	42.6	9.34	23.26
AES	31.66	56.15	17.29	30.66

5.3.2 Switching to Energy Efficient Appliances in Residential Sector (Cooling)

Air conditioners, refrigerators and ceiling fans are the major cooling appliances in residential households. Currently, these appliances comprise ~72 percent of the total residential energy consumption. Although a survey of star rated appliances is absent within the LPA, the district profile from IRES survey suggest an absence of 5-star rated appliances, where Brushless Direct Current (BLDC) fans lack outreach in the nearby districts. Further, only 27 percent of the current refrigerator and air conditioner stock in use has a 3-star rating. Therefore, it is crucial to increase penetration of star rated appliances in the residential sector. Table 17 shows the potential for electricity savings within the cooling sector and mitigation potential by 2041.

Table 17: Appliance Electricity Savings and Abatement Potential by 2041

Appliance	Electricity Savings (GWh)	Stock of appliances in 2041	GHG Abatement potential ($ktCO_2e$)
Refrigerator	21.2	1,00,000	12
Air Conditioner	23.5	11,000	13
Ceiling Fans	3.6	2,15,000	3

5.3.2 Switch to LED-based Lighting

Switching to LED-based lighting has a tremendous potential for energy efficiency in both residential as well commercial sectors in Rajapalayam LPA. There is a potential to conserve 4.26 to 6.2 GWh by 2041 in the residential sector by replacing inefficient lighting fixtures, while in the commercial buildings and public services, 3.2 to 4.3 GWh of electricity consumption savings is possible. This can lead to a total potential abatement of 5.6 $ktCO_2e$ (See Table 18).

Table 18: Electricity Consumption Savings and GHG Emissions Mitigation Potential from LED in 2041

Appliance	Electricity Savings (GWh)	Stock of appliances in 2041	GHG Abatement potential ($ktCO_2e$)
Residential LED	6.1	6,00,000	3.4
Street Light LED	4.3	10,000	2.2

5.4 Cooking Fuel Switching

5.4.1 Electrification of Residential Cooking

Currently, a substantial number of households within the LPA region use LPG as a cooking fuel (88 percent) whereas only 3 percent rely on biomass, with the remaining use electric cooktops for cooking. As the share of electricity in total energy consumption increases, more LPG cylinders are expected to be avoided in the Rajapalayam LPA. Table 19 shows the abatement potential from LPG as well the number of cylinders that could be abated by 2030 and 2041 under the scenarios discussed. It is thus anticipated that electricity consumption from the cooking segment itself could increase from 27-58 GWh (See Table 19). Abatement potential due to shifting to electrified cooking is 1 $ktCO_2e$.

Table 19: LPG Energy Demand Abatement and Electricity Consumption by Fuel Switching

Year	LPG Primary Energy demand Abated (PJ)		Number of LPG Cylinders avoided		Electricity Consumption (GWh)	
	MES	AES	MES	AES	MES	AES
2030	0.09	0.17	1,18,922	2,24,630	14.5	26.9
2041	0.24	0.44	3,17,125	5,81,395	37.1	58

5.4.2 Biogas for Cooking

Rajapalayam has the potential to generate 3500 m^3/day of cow dung from livestock. For utilising this, Rajapalayam LPA could potentially install a biogas plant of approximately 3500 m^3/day capacity. This could thus yield 1750 m^3/day biogas which could be either bottled or piped for consumption in the domestic cooking sector. Thus, this capacity would be enough to replace 10,741 LPG cylinders i.e. 2 percent of the total capacity by 2041. Thus, it is estimated that 1.6 ktCO_2e can be abated.

5.5 Waste and Land Management

5.5.1 Solid Waste Management

GHG emissions projected for solid waste disposal are observed to be rising. This can be attributed to a growing population, increase in per capita waste generation, changing waste composition, and inadequate levels of waste processing over the emissions estimation period.

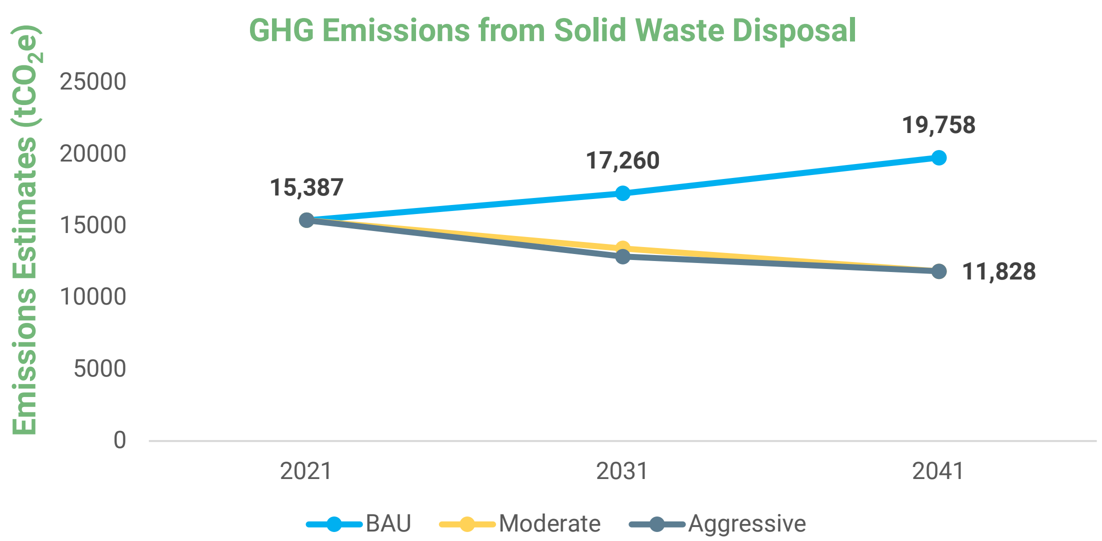


Figure 20: GHG Emissions from Solid Waste Disposal

Recommendations:

Composting and Waste Treatment Plants

Composting is considered as a key process in solid waste management and plays an important role in reducing the volume of domestic biodegradable waste that goes to landfills[17]. It is projected that in the MES, additional capacity of 11 tonnes per day (TPD) and 21 TPD of compost plants would be required in 2031 and 2041, respectively. In AES, 13 TPD and 21 TPD of compost plants would be required in 2031 and 2041, respectively (see Table 20). With respect to dry waste treatment, as per the projections, under MES, recycling units of capacities 8 TPD and 21 TPD would be required in 2031 and 2041, respectively. While in AES, recycling units of capacities 12 TPD and 21 TPD would be required in 2031 and 2041, respectively.

Table 20: Required Installed Capacity of Wet Waste Treatment Plants in Moderate and Aggressive Scenarios

Composting	MES		AES	
	2031	2041	2031	2041
Requirement (in TPD)	11	10 (Additional Requirement)	13	8 (Additional requirement)

Other recommendations:

- Encourage segregation and collection of waste at source.
- Promote resource utilisation through reuse, recycle and recovery.
- Install community waste bins with sensors to monitor volume and optimise routes of waste collection vehicles.
- Encourage and promote composting, vermi-composting and biogas plants at household and community-level.
- Encourage 100 percent waste recycling through Waste to Energy, Material Recycling Facility and Refuse Derived Fuels.
- Promote use of plastic waste for road construction.
- Facilitate and conduct Behaviour Change Communications workshops on proper disposal of solid waste.
- Encourage awareness campaigns to reduce single use plastics and promote use of sustainable products.

5.5.2 Circular Economy: Waste

- 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

17. Atalia, K. R., Buha, D. M., Bhavsar, K. A., & Shah, N. K. (2015). A review on composting of municipal solid waste. Journal of Environmental Science, Toxicology and Food Technology, 9(5), 20-29.

materials for the production.

- Incentivise the informal sector and build public-private partnerships for proper segregation, collection and disposal of waste.
- Introduce and strengthen Extended Producer Responsibility guidelines for plastic and e-waste management.

5.5.3 Shift in Agricultural Production

As mentioned in the earlier sections, projected emissions from rice cultivation in Rajapalayam LPA can be seen decreasing from 2021 to 2041. This decline can be attributed to the reduction in area under rice cultivation. In MES, where 50 percent of the cultivated area is expected to follow single aeration with System of Rice Intensification (SRI) by 2041, emissions are anticipated to decrease from 8,991.96 tCO_2e to 2,255.85 tCO_2e. In AES, with 100 percent multiple aeration is expected with SRI by 2041, emissions are anticipated to decrease from 8,991.96 tCO_2e to 151.97 tCO_2e (see Figure 21).

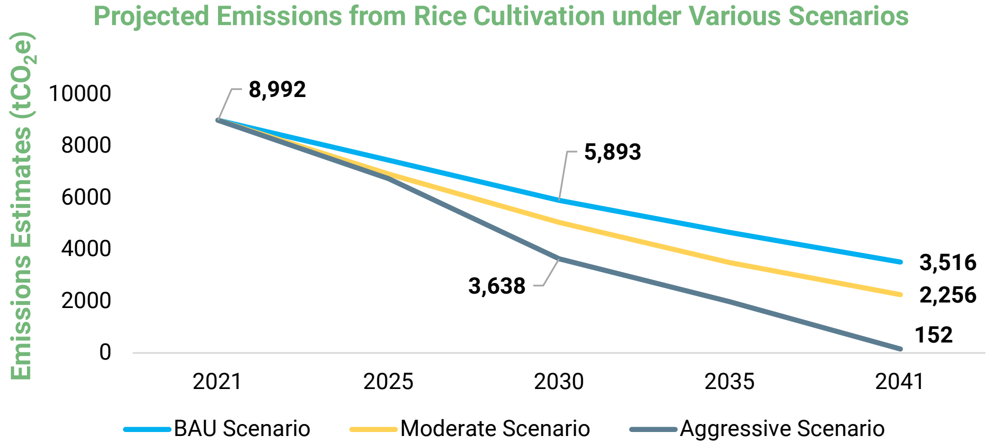


Figure 21: Projected Emissions from Rice Cultivation Within All Scenarios

Recommendations

System of Rice Intensification (SRI) can reduce methane emissions by 61.1percent.[18] The SRI presents an efficient approach to address methane emissions through a nature-centric method. It promotes aerobic soil conditions by employing Alternate Wetting and Drying (AWD). This technique permits the soil to come into contact with oxygen, effectively neutralising methanogens. Additionally, SRI has demonstrated the ability to increase aerobic bacteria, specifically methanotrophs, which actively consume methane. Moreover, the technique has the potential to enhance rice yield by 36-49 percent with about 22-35 percent less water than conventional transplanted rice.[19]

Direct Seeded Rice serves as an effective strategy for mitigating methane emissions in rice cultivation. This method minimises methane release by eliminating the need for raising nurseries, puddling, and transplanting. In contrast to traditional transplanted paddy cultivation, the system doesn't maintain standing water. Another approach to prevent methane emissions is diversifying crops from paddy to alternative options such as pulses, oilseeds, maize, cotton, and agroforestry.

18. Jain, N., Dubey, R., Dubey, D.S. et al. Mitigation of greenhouse gas emission with system of rice intensification in the Indo-Gangetic Plains. Paddy Water Environ 12, 355–363 (2014). https://doi.org/10.1007/s10333-013-0390-2
19. Measures to reduce methane emissions, Ministry of Environment, Forest and Climate Change https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1942106

5.5.4 Agricultural Soil

In MES, where 50 percent[20] of chemical fertiliser is projected to be replaced by organic fertiliser by 2041, emissions are anticipated to decrease from 1,106.10 tCO_2e to 216.26 tCO_2e. Under AES, with the complete replacement of chemical fertiliser by organic fertiliser by 2041, emissions are expected to decrease from 1,106.10 tCO_2e to zero, which implies that under this scenario, there will be no emissions from agriculture soils. (See Figure 22).

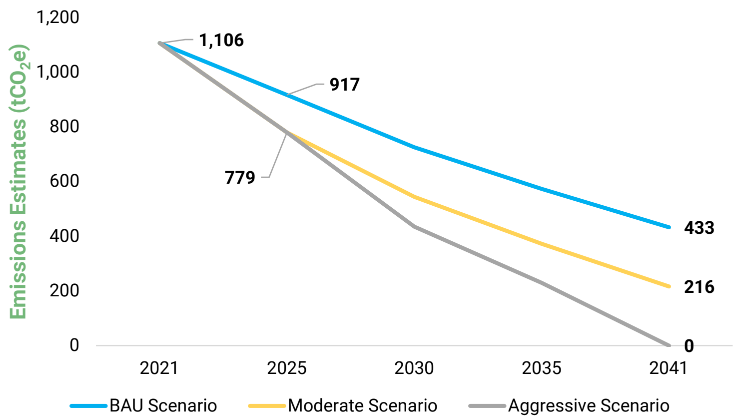


Figure 22: Projected Emissions from Agriculture Soils Under Various Scenarios

In addition, it is also recommended to:

a. Promote and encourage use of organic manure, bio-pesticides and 'zero budget natural farming' practices.
b. Encourage use of decision support tools for effective input/nutrient management.
c. Encourage and promote use of Nano Urea fertilisers.

5.5.5 Livestock

Use of alternate feed supplements can be encouraged within the Rajapalayam LPA to decrease emissions from livestock. ICAR-National Institute of Animal Nutrition and Physiology has developed a feed supplement - Harit Dhara and Tamarin Plus, for cattle, buffalo and sheep. The supplements are effective in cutting down enteric methane emissions by 20 percent[21]. With the use of these feed supplements, a cumulative GHG emissions abatement of 39,813 tCO_2e, or an average of 1,896 tCO_2e per year could be achieved. This is illustrated in Figure 23.

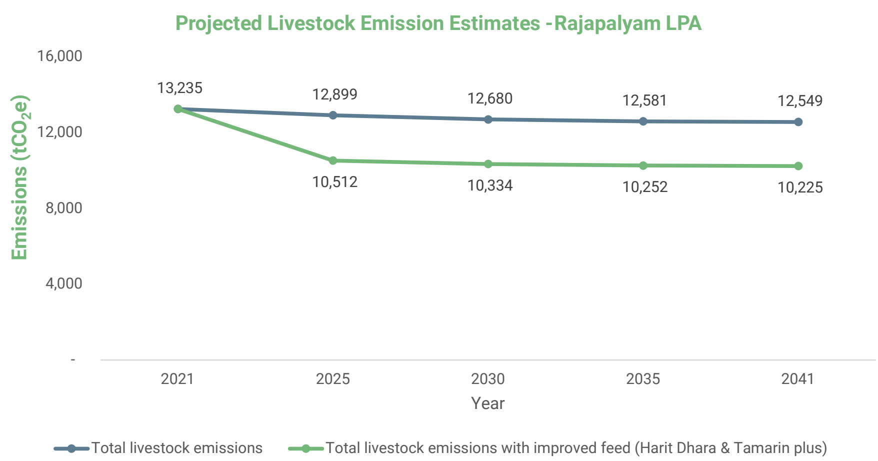


Figure 23: Projected Emissions from Livestock Under Various Scenarios

20. https://loksabhadocs.nic.in/lsscommittee/Chemicals%20&%20Fertilizers/17_Chemicals_And_Fertilizers_39.pdf

21. http://nianp.res.in/harit-dhara-tamarin-plus

5.5.6 Wastewater Treatment

The characteristics of domestic wastewater and consequently the associated GHG emissions can vary depending on factors such as economic status, community food intake, water supply status, treatment systems and climatic conditions of the area. GHG emissions from wastewater from the year 2021 to 2041 in Rajapalayam LPA across various scenarios (BAU, moderate and aggressive) are shown in Figure 24.

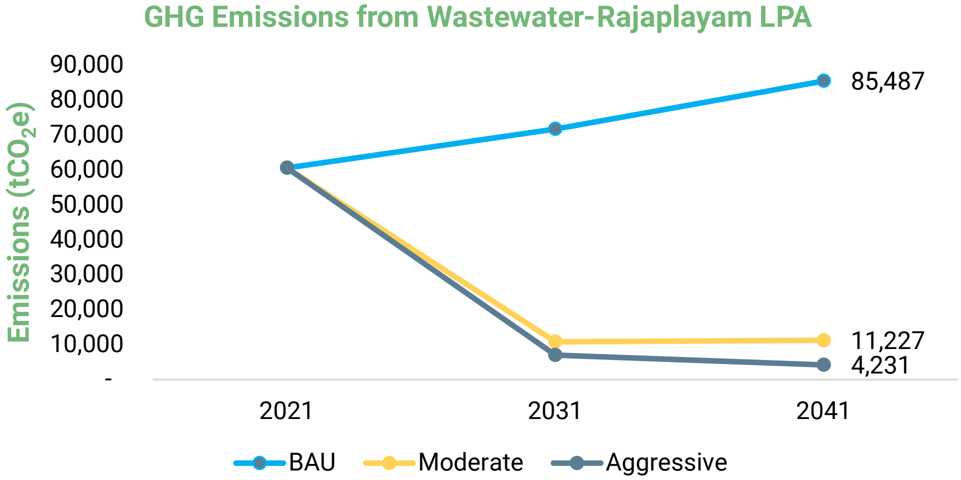


Figure 24: Projected Emissions from Wastewater under Various Scenarios

To abate GHG emissions from wastewater, it is recommended to

- Ensure 100% underground drainage (UGD) connection for the urban areas to ascertain 100% utilization of the existing 21.85 MLD STP, which is currently operational at 7 MLD capacity.
- 3 DEWATS along with simplified sewer system for 3 high density villages namely Kadambankulam, Samusigapuram, Ramalingapuram
- Twin pit septic tanks for 35137 households of the other 10 revenue villages.
- 1 FSTP across all the 10 Revenue Villages of Rajapalayam LPA

5.5.7 Agriculture Waste

In the BAU scenario, emissions from agriculture waste in 2041 are expected to decreased by 46.1 percent since the agriculture land in Rajapalayam LPA is decreasing. In the moderate scenario, where 50 percent agriculture waste is projected to be treated at biomethanation plants by 2041, emissions are anticipated to decrease from 60,686.5 tCO_2e to 16,354.17 tCO_2e. Under the aggressive scenario, with all the agriculture waste being treated at biomethanation plants, emissions are expected to decrease from 60,686.5 tCO_2e to 0 tCO_2e by 2041(See Figure 25).

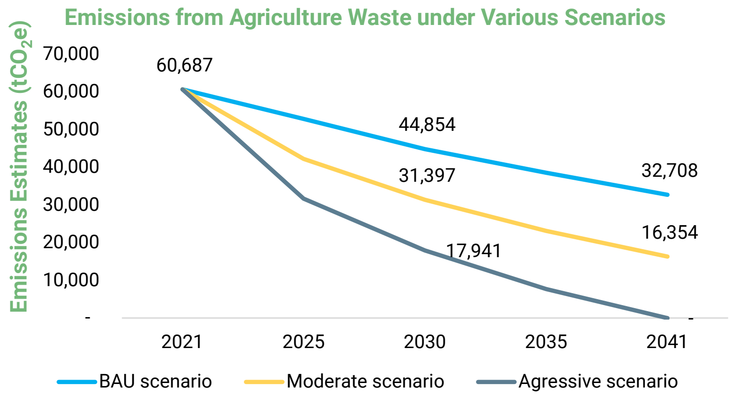


Figure 25: Projected Emissions from Agriculture Waste under Various Scenarios

5.5.7 Sustainable Farming Practices

In addition to the above, following activities can be initiated to transition to more sustainable agricultural 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.
- Land under rice cultivation can be diversified to other crops by promoting cultivation of millets which require less water and are drought resistant. This can help in reducing emissions from the agriculture sector.
- 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 timings for sowing, harvesting and irrigation.
- Solar powered cattle sheds can be built to enable dung collection at scale for utilising quality dung for use in biogas plants, organic fertiliser for crops etc. The solar capacity installed can be utilised in maintenance of the livestock as well as for other farm activities.

5.6 Afforestation and Restoration

The afforestation and restoration plans for Rajapalayam have been prepared factoring in current levels of forest and plantation already in the area and also factoring in the current sequestration levels of the existing reserve forests and other plantations.

The current rate of sequestration, which is assumed in the 'Business as Usual Scenario' will help in sequestering around 22,930 t CO_2e (cumulative) by 2041, i.e. an average annual sequestration of 1145 tCO_2e.

However, with the proposed plans, the sequestration potential for the area is projected to increase by almost 36 times as detailed below.

The proposed plans recommend a twin approach: (a) creating additional sinks in the urban pockets of Rajapalayam LPA; and (b) by carrying out rigorous restoration activities in the degraded pockets of the iconic, religious and cultural significance "Sanjeevi Malai".

5.6.1 Additional Sinks in the Urban Pockets

The Master Plan - 2041 for the LPA approved by the Government of Tamil Nadu has clearly made provisions for enhancing green spaces and plantations across the land areas categorised as "Non-Urban Land" "Urbanisable Land" and "Aquifer Recharge Areas." The land parcels for all these categories have a total area of 3,140 ha. Again, factoring in the various other provisions made in the Master Plan for Rajapalayam, it has been estimated that 50 percent of the total area for the above mentioned categories would be suitable to carry out the plantation and for the development of green spaces. These plantations activities can be carried out in the land areas that are categorised as 'Non-Urban Area', 'Urbanisable Area' and 'Aquifer Recharge Area'. As per the Master Plan, the category 'Non-Urban Area' not only includes the fallow land of Rajapalayam LPA but also comprises of the demarcated buffer zones around the 42 water bodies of the LPA. Further, based on peer review and expert opinion, the sequestration potential for the identified species of trees and plants (see Table 21), has been arrived at. The approach taken is considered robust to estimate the sequestration potential, Figure 26 presents two scenarios for plantations and their sequestration potential. Furthermore, the sequestration potential estimated have been done for two scenarios, one the moderate scenario wherein the density of plantation is kept to a minimum, while in the aggressive scenario, subject to availability of adequate plants and resources, the density of plantation has been assumed at the most optimum level. To elaborate, in the moderate scenario, high value trees like timber are planted at a density of 250 per hectare, while in the aggressive scenario, trees of multiple species are planted at a density of 600 per hectare.

Figure 26 illustrates the two scenarios of the carbon sequestration potential for the Rajapalayam LPA. Primarily, in the moderate scenario, the cumulative sequestration would be around 6,47,625 tCO_2e while in the aggressive scenario, it would go up by 20 percent, which is 7, 77,150 tCO_2e[22]. Moreover, this intervention will not only help to enhance the sequestration of the Rajapalayam LPA but would also build overall resilience of the area. The green spaces around the water bodies will act as recreational spaces for the locals. Additionally, the co-benefits of the plantations or green spaces will lead to water recharge, soil conservation, reduction in urban heat island effect and enhancing biodiversity.

Table 21: Identified Species of Trees and Plants Suitable for Plantation in Rajapalayam LPA

Plantation of Fallow Lands		**Water Buffer Zones**	
1.Dalbergia latifolia	**Rosewood**	*1.Terminalia arjuna*	**Arjun**
2.Santalum album	**Sandalwood**	*2.Pongamia pinnata*	**Punga**
3.Pterocarpus marsupium	**Vengai**	*3.Barringtonia actuangularia*	**Freshwater mangrove**
4.Pterocarpus santilinus	**Red Sanders**	*4.Mangifera indica*	**Mango**
5.Ailanthus excelsa	**Tree of heaven**	*5.Syzygium cumini*	**Jamun**
6.Terminalia chebula	**Myrobalan**	*6.Bauhinia racemosa*	**Bidi Leaf tree**
7.Chloroxylon swietenia	**Satin wood**	*7.Maduca longifolia*	**Mahua**
8.Hardwickia binata	**Anjan**	*8. Ficus amplissima*	**India bat fig**
9.Albizzia lebbeck	**Indian Siris**	*9. Ficus racemosa*	**Cluster fig**
10.Tectonia grandis	**Teak**	*10.Acacia niliotica*	**Babul**

22. Expert Inputs and Literature Review (eg: Global carbon dioxide removal rates from forest landscape restoration activities. Blanca Bernal* ,Lara T. Murray and Timothy R. H. Pearson)

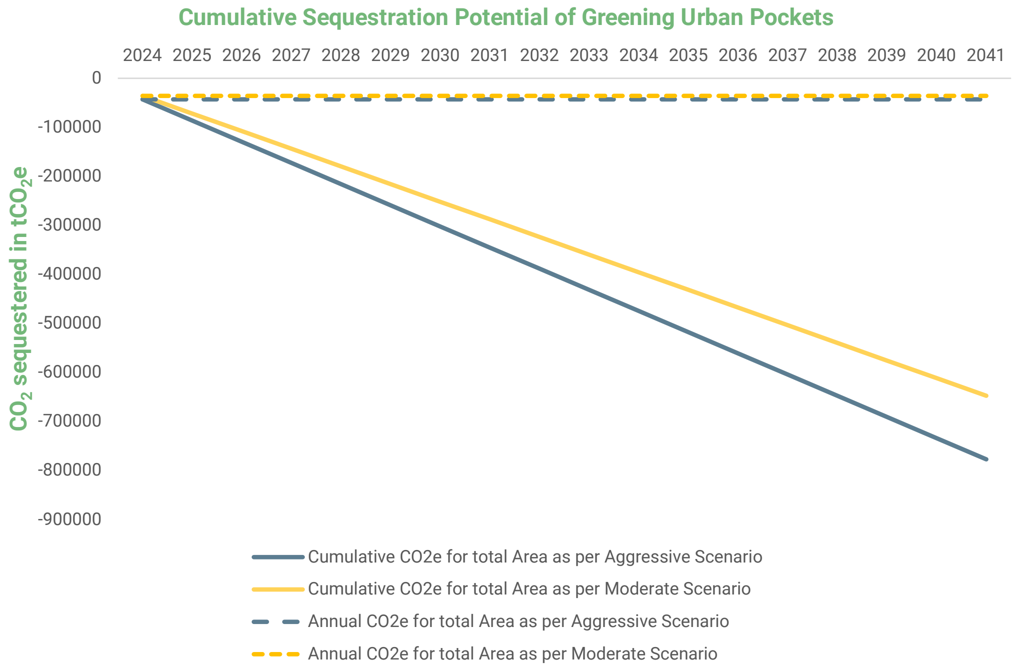


Figure 26: Sequestration Potential of Plantation Activities in Non-urban Use Zone in Rajapalayam LPA

5.6.2 Sanjeevi Malai Restoration and Creation of Sanjeevi Malai Eco-Park:

Through expert inputs, literature review and peer review of calculations, it is assumed that 40 percent of the total area of Sanjeevi Malai needs rigorous restoration that would help to sequester 33,116 tCO_2e by 2041, with an average annual sequestration of 1,840 tCO_2e.

Plan of Action (PoA) for the Greening of Sanjeevi Malai – Rajapalayam [23]

This plan of action should be read in conjunction with the 'Report of Sanjeevi Malai March 2022' as it contains all the background information required to understand the context. This PoA is intended to set out the actionable points to follow over the next 3-5 years to make the project a model project of assisted natural regeneration, which can serve as a prototypic approach for other such areas.

The aim of the project is to identify and then re-green the areas on the hill which are currently either overrun by lemon grass or are dominated by monocultural plantations of two species – namely *Acacia planifrons* and *Tectonia grandis*. Additionally, it aims to remove the presence of *Prosopsis juliflora* - (Madras thorn - an invasive exotic) - from the hill.

Not all areas are suitable for tree plantation due to the presence of exposed sheet rock, and in areas adjacent to this area with extremely thin soils. Where this is the case, the aim will be to restore the areas with appropriate shrubs, sub-shrubs and native grasses.

The regreening of Sanjeevi Malai has the following challenges that need to be addressed and dealt with to make it a success. They are:

23. Developed by Mr Paul Blanchflower, Auroville Botanical Gardens

Grazing on the Hill
The presence of goat herds and cattle on the mountain – many of goats are left there overnight. It will not be possible to plant saplings and expect them to survive if a solution to this problem is not negotiated to the satisfaction of all the stakeholders involved. It will require delicate social engagement with the herd owners to find a way to address their needs and create a goodwill from them towards the success of the project. The solution is not immediately obvious and will require patient dialogue and skilled social workers who are able to work towards a satisfactory conclusion. If this is not done then the chances of a successful project are minimal, so it is better to wait until this issue is resolved before any large-scale interventions are implemented.

At the outset of the project this social aspect needs to be the first priority and funds need to be set aside to go deeply into the issue and search for the correct approach. The group involved will need to gain the trust of the local people, enter the process with a sense of humility and drop any preconceived ideas of what the solution should be so that they are open to working with the stakeholders to find a solution.

Summer Fires
Each year the lemon grass on the hill catches fire, either accidently or it is set purposefully. Any fire damage to young seedlings inevitably results in the fatality of the young trees, thus it is important that the fire risk is managed and that there is a clear action plan to reduce the ability of the fires to spread – through a system of cleared fire breaks as well as the cleaning of areas prior to the plantation of seedlings. This may well result in one or two years of increased soil erosion, but in the long term the establishment of a native tree and shrub cover will ensure minimal erosion.

The remote sensing mapping of the fire prone areas, and ground truthing of these maps to identify the trajectory of the fire lines, will be the first step in this process. The actual work of clearing the fire lines, will be the first work on the ground and can be offered to local stakeholders. The work carried out in Tiruvanamalai is an excellent example of how this can be achieved and it a good idea that a site visit there would be well worth the effort.

Once these two issues have been addressed and clear pathways have been established to deal with them, then the major plantation work can begin. Resources must be mobilised and studies made to understand the best way to establish plants on the hills, and to ascertain if during the dry season some form of after care is a requirement. The species list attached to the previous report still holds good, and the setting up of dedicated nurseries that focus on these species is another task that needs to be undertaken at the earliest opportunity. There are a certain number of seedlings already available in the native tree nursery at the polytechnic in the town, but this will need to be supported and energy focused on seed collection for the desired seedlings to be available in the numbers required.

At this stage we can outline a plan of action, that can be followed for the next 3 to 5 years, but it is clear that the detailed plan will have to be written and developed by the project team as the work unfolds – particularly with respect to the grazing issue as we do not know it will be possible to completely eradicate grazing from the hill or if we will be able to reach agreements to ensure certain parts of the hill are not grazed. Additionally, decisions need to be made about any interventions that can be made with the two monocultural species present, *A.planifrons* and *T.grandis*. Currently, it is felt that there is no need to remove them, but that a program of under planting them, will give the desired long-term results. However with respect to *P.juliflora,* eradication might be the best approach.

Further, an additional initiative that can be undertaken is **'Creation of Eco-park at the base of Sanjeevi Malai on 44 acres of Bhoomidan lands'.**

Target set for 2041: Design and implementation of the eco park, that not only promotes the conservation of biodiversity and carbon sequestration plantations (both on Sanjeevi Malai and in the LPA) but it will also showcase all of the latest technologies for alternative energy as well as energy efficiency. It will in fact become the Carbon Neutral Hub for Rajapalayam, which will serve an immense role in the education for behavioural change required in the highest level pathway proposed as Aggressive Behavioural Change Scenario (ABS). The year-wise plan is provided in the section - 'Year-on-Year Interventions - Other Sectors'.

Phase 1 – January 2024 – April 2024

- Establish a community led body to oversee the design and implementation of the project. This can follow existing provisions within the forest department, such as the 'Eco Development Committee'.
- See how the development can relate to the local tribal populations and if they are present, how their economic aspirations can be integrated into the development plan. This work can be combined with the local community engagement.
- Locate all temples and shrines within the area, understand the legislative aspects of them and see how to integrate them into the overall plan.
- Review the household survey that was carried out as part of the town planning exercise and see what other data might be pertinent to gather. Design the new survey and carry it out.
- Evolve a plan for social engagement – with respect to grazing and any other issues that come up. Map the various stakeholders and develop a strategy for meaningful engagement.
- Planning of fire management strategy – learning from the experiences of the team in Thiruvannamalai through a field visit there and invite that team to Sanjeevi Malai.
- Review of previous botanical survey and mapping of area – can this be improved and done with a greater degree of accuracy – and if so, what benefits would it bring?
- Carry out soil tests on the hill, with an aim to understand both the current nutrient status as well as the current carbon profile of the soil.
- Identify any other baseline studies that should be undertaken – such as butterflies, reptiles, small mammals and birds.
- Detailed survey of potential planting areas – with respect to soil depth and appropriate species.
- Assessment of existing monocultural stands with a view to their management.
- Development of a long-term strategy to deal with historic encroachments and to prevent further encroachments.
- Reach out to various funding agencies to see if they would be willing to support some of the work on the hill – either plantation or planning.

For all of the above we need to review all possible interventions and decide which ones are cost effective and which ones have the highest chance of success. For example, the idea of fencing the entire perimeter of the hill have been suggested at times – but will this help prevent grazing, however, it will cost very high.

Phase 2 - April 2024 – August 2024

- Initiate and undertake required baseline studies.
- Assess the current carbon sequestered on the hill through interpretation of soil studies and satellite data of the existing canopy. Consequently, establish a protocol, so that future carbon credits can be accrued for the work carried out – with the intention that the local community become the direct beneficiaries.
- Development of planting strategy, methods of plantation and consequently identifying appropriate species – dependent upon if some form of aftercare is possible etc.
- Developing a yearly plan for the plantation with number of seedlings and areas for plantation.
- Implement the devised social plans for reducing the grazing on the hill
- Clear the first fire lines and create protocols for dealing with fire on the hill – perhaps with voluntary groups that can be organised to beat the fires out.

Phase 3 - August 2024 onwards

- Start the planting and aftercare programs.
- Continue with the required studies to monitor the program and provide feedback for adaptive monitoring.

As we are already aware that there are approximately 100 hectares of land to be replanted, we could imagine that the plantation work is spread over five years, with the initial plantation being on a smaller scale to ensure the protocols are working before scaling up. Thus, we might expect to plant 5-10 hectares in the first year, with 2,500 to 5,000 plants per hectare – depending on the plantation strategy developed. In subsequent years this could be increased to 20 hectares per year, with some areas of replanting each year if there are problem areas. Totally we would expect to plant anywhere between 2.5 lakh to 5 lakhs trees over the five year program.

Aspects for Forestation and Enhancing Green Spaces

- Soil characteristics such as fertility, pH levels, nutrient availability and drainage capabilities need to be determined for each site to select suitable species.
- Identify tree species that are native to the region and well-adapted to the local climate and soil conditions.
- Promote biodiversity by planting a mix of tree species to enhance ecological balance and resilience.
- Implement soil conservation measures, such as contour plowing and mulching, to prevent soil erosion around tree plantations.
- Develop water conservation strategies and irrigation systems to support tree growth, especially in the initial stages.
- Protect the trees by creating fences or installing tree guards particularly in the initial stages.
- Engage the local community in tree planting initiatives, to develop a sense of ownership
- Establish a robust monitoring and maintenance system to ensure the health and growth of the planted trees.
- Integrate tree planting with agricultural activities through agroforestry.
- Conduct awareness campaigns to educate the local community about the importance of tree plantations for environmental conservation.

Blue carbon ecosystem and water body restoration of Rajapalayam LPA

Mitigation Potential Strategies for Water Bodies in Rajapalayam LPA

Rajapalayam, located in a semi-arid region[24], is home to a large number of water bodies, which cover approximately 13.27% of its total area. These water bodies, primarily fed by streams originating from the Western Ghats, play a crucial role in sustaining the agricultural practices and water needs of the city[25]. Mudangiyaru River at Ayyanar Kovil, a major water body in Rajapalayam, is a primary source of water for irrigation in the region[26]. Additionally, Rajapalayam has 42 major water bodies, out of which 39 are used for farming. These water bodies form an important part of catchment for the Upper Vaippar basin.

Despite having adequate water bodies, these tanks are often dry due to the prevailing climatic conditions of the region. Over-extraction of groundwater has led to Rajapalayam being classified as 'critical'[27] , further threatening the sustainability of its water resources.
In addition to the detailed water management action plan outlined in the Master Plan for Rajapalayam LPA 2041 - Volume 24, the following innovative practices aid water body restoration and vegetation growth to promote carbon sequestration, thereby enhancing the blue carbon ecosystem of Rajapalayam.

Floating Treatment Wetlands (FTW)

Floating Treatment Wetland is an innovative phytoremediation practice that uses artificial floating structures consisting of buoyant platforms to support hydroponically grown plants. The plant roots hang directly and extend into the water, creating a habitat for microorganisms that aid in breaking down pollutants. The plants also support the growth of a biofilm on their roots which absorb and degrade contaminants such as nitrogen, phosphorus and other contaminants. By promoting the natural filtration process, FTWs can enhance water quality, reduce nutrient loads, and improve the overall health of aquatic ecosystems.

Bioengineering solutions

This practice involves the use of bioengineered barriers for groundwater recharge and to filter contaminants entering water bodies, thereby preventing sediment buildup. Further, the desilted organic materials can be used for stabilising exposed soils, thereby enhancing the soil organic carbon.

24 https://twadboard.tn.gov.in/sites/default/files/Rajapalayam-UGSS-Draft-IEE_0.pdf

25 https://rajapalayamlpa.com/wp-content/uploads/2024/03/print_final_volume1_20240229.pdf

26 https://cdn.s3waas.gov.in/s3c86a7ee3d8ef0b551ed58e354a836f2b/uploads/2023/01/2023010298.pdf

27 https://rajapalayamlpa.com/wp-content/uploads/2024/03/print_final_volume2_20240229.pdf

In-Situ Bioremediation

In-situ bioremediation involves adding beneficial microbes and enzymes directly into the waterbody to break down organic matter and degrade contaminants directly within the water body. Microorganisms like bacteria, fungi and yeast metabolize pollutants by converting them into less toxic products, aid in reducing sludge and neutralizing harmful chemicals. This also removes foul odor and improves dissolved oxygen levels, thereby minimizing ecological disruption and preserving the natural habitat.

Solar Powered Aerators

Solar powered aeration systems create water movement on the surface and introduce oxygen into the water to reduce eutrophication and improve the water quality. This prevents stagnation and stratification of water thus reducing the nutrient buildup that leads to algae proliferation, improves the aquatic habitat by enhancing dissolved oxygen levels and avoids formation of anaerobic zones thus minimizing foul odors and other harmful gases. Additionally, the solar powered aerators reduce the dependence on fossil fuels and have a low operational cost after installation.

The aforementioned initiatives are in addition to the plantation activities recommended (in the section above) along the buffer zone of the water bodies, which in turn has the potential to sequester 14.5 kt CO_2e per annum.

Rajapalayam LPA Vision 2027

GREEN SPACES & CARBON SEQUESTRATION	Restoration and conservation of existing forest area and tree cover (i) Dedicated restoration and afforestation efforts for Sanjeevi Malai (ii)Strengthening and protection around existing reserved forest areas.	Restoration and afforestation of (a) 111 ha, 40% of Sanjeevi Malai and (b)422 ha of the other two reserved forests • Identification of plant species, acquiring, planning, laying the ground for the plantation. • Plantation activity and a system for plant protection and maintenance of the plantation	0.46% 3.3 kt CO_2e	0.38% 2.94 kt CO_2e	4 Crore
	(iii)Creation of Eco-park at the base of Sanjeevi Malai on 44 acres of Bhoomidan lands	Functional ecopark and educational programmes	NA	NA	11 Crore
	Increasing tree cover in non-urban zone by planting indigenous and high value trees in: (i) Buffer zones (industrial , landfill, STP), (ii) Along roads and pedestrian pathways (ii) Reserved forest buffer zone and around water bodies	Plantation in 1570 ha, i.e., 50% of Non-urban + Urbanisable + Aquifer recharge areas	5.97% 43.2 kt CO_2e	5.55% 43.2 kt CO_2e	10 Crore
	Vertical gardens at strategic locations (markets, under flyovers, walkways)	60 vertical gardens of at least 100 square feet/unit	NA	NA	1.5 Crore
	Total of Green Spaces		6.42% 46.5 kt CO_2e	5.93% 46.14 kt CO_2e	26.5 Crore
MUNICIPAL SOLID WASTE MANAGEMENT	Segregation at source through colour coded bins	100% segregation at source	0.33% 2.4 kt CO_2e	1.03% 8 kt CO_2e	4.5 Crore
	Waste processing stations	T62 TPD transfer and processing facilities			2 Crore
	EVs for waste collection and transfer	4 e-collection vehicles			0.4 Crore
	Community based composting/ vermicomposting units	21 TPD wet waste processing facility			1.5 Crore
	Total of Municipal Solid Waste Management		0.33% 2.4 kt CO_2e	1.03% 8 kt CO_2e	8.4 Crore
PLASTIC WASTE MANAGEMENT	Use of plastic waste for road construction	8% plastic mix in all new road construction activities	NA	NA	0.5 Crore
	(i) Handicrafts from non-recyclable plastic waste (ii) Eco-friendly alternatives to single-use plastics	10 units by engaging local communities and, SHGs			1 Crore
	Plastic waste palletization recycled	100 kg/hr shredder unit			0.2 Crore
	Total of Plastic Waste Management		NA	NA	1.7 Crore
WASTEWATER MANAGEMENT	Enhance UGD connection	60 % UGD	6.15% 44.5 kt CO_2e	11% 85.6 kt CO_2e	To be assessed
	DEWATS along with simplified sewer system	3 DEWATS along with simplified sewer system for 3 high density villages namely Kadambankulam, Samusigapuram, Ramalingapuram			4.5 Crore
	Twin-pit septic tanks and FSTP at village level	1 FSTP + twin pit septic tanks for 35137 households of 10 revenue villages			18 Crore
	Total Wastewater Management		6.15% 44.5 kt CO_2e	11% 85.6 kt CO_2e	22.5 Crore

Strategy | Target for 2027 | 2027 Annual Mitigation Potential | 2041 Annual Mitigation Potential | 2027 Financial Requirement*

Sector	Strategy	Target for 2027	2027 Annual Mitigation Potential	2041 Annual Mitigation Potential	2027 Financial Requirement*
SUSTAINABLE AGRICULTURE PRACTICES	Diversion of land under rice cultivation to millets	100 ha (5%) diverted	0.05% 0.34 kt CO_2e	0.32% 2.5 kt CO_2e	NA
	Mixed cropping and multi layer cropping of rice cultivation area	285 ha (10%) shifted	NA	NA	NA
	SRI + Shifting rice cultivation water regime from continuous flooding to multiple aeration	20% shifted	0.18% 1.30 kt CO_2e	0.44% 3.4 kt CO_2e	1.22 Crore
	Organic fertiliser instead of urea	30% area transitioned	0.03% 0.25 kt CO_2e	0.06% 0.43 kt CO_2e	5.68 Crore
	Mini weather monitoring stations to forecast extreme weather conditions	10 stations	NA	NA	0.2 Crore
	Livestock feed additives to reduce methane emissions	20% of cattle fed with improved feed	0.33% 2.37 kt CO_2e	0.30% 2.32 kt CO_2e	1 Crore
	Total of Sustainable Agriculture Practices		0.59% 5.36 kt CO_2e	1.11% 9.75 kt CO_2e	8 Crore
HARNESSING RENEWABLE ENERGY POTENTIAL	Installing Solar rooftop across residential home under PM Suryaghar Muft Bijli Yojana and prioritizing rooftop solar on all government building (MNRE mandate for 2025)	To achieve 40 MW of additional rooftop capacity	6.44% 46.6 kt CO_2e	22.61% 176 kt CO_2e	220 Crore
	Installation of solar pumps to replace existing diesel pumps in the LPA under PM KUSUM scheme (Component B)	To add 300 number of agricultural solar pumps (total diesel pumps in LPA are ~ 3000)	0.19% 1.4 kt CO_2e	0.41% 3.64 kt CO_2e	7.5 Crore
	Creating additional Renewable Energy generation sources in the LPA region		NA	37% 287 kt CO_2e	NA
	Decarbonising Electricity consumption by harnessing RE in the industries		NA	6% 38 kt CO_2e	NA
	Total of Harnessing Renewable Energy Potential		7% 48 kt CO_2e	66% 504.64 kt CO_2e	227.5 Crore
ROAD TRANSPORT ELECTRIFICATION	Addition of electric 2 Wheelers, 3 Wheelers and Electric buses on priority	Addition of electric 2 Wheelers, 3 Wheelers and Electric buses on priority	0.25% 1.79 kt CO_2e	2.31% 17.93 kt CO_2e	58.5 Crore
		Total of 25 E-buses to be introduced in the public transport segment	0.03% 0.23 kt CO_2e	0.54% 4.2 kt CO_2e	30 Crore
		A total of 250 passenger 3 wheelers EV and 250 commercial 3 wheelers EV to introduced till 2027	0.1% 0.73 kt CO_2e	0.84% 6.56 kt CO_2e	15 Crore
	Shift to private electric mobility	A total of 4500 4-wheelers to be introduced till 2041	NA	1.6% 1.983 kt CO_2e	NA
	Total of Road Transport Electrification		0.4% 2.75 kt CO_2e	4% 30.673 kt CO_2e	103.5 Crore
ENERGY EFFICIENCY AND FUEL SWITCHING	Residential households to shift to electric cookstoves to reduce reliance on LPG and biomass	5000 electric cook stoves to replace conventional LPG gas stoves and biomass usage	0.05% 0.32 kt CO_2e	0.15% 1.1 kt CO_2e	2 Crore
	Annual Electricity saving potential as per industrial energy efficiency interventions		NA	4% 30.66 kt CO_2e	NA
	Adoption of super energy efficient appliances in households (Fans,Space Cooling Units, Refrigerators)		NA	4% 34 kt CO_2e	NA
	Adoption of LED lighting to replace conventional source (incandescent , CFL) of lighting sources	60000 LED bulbs to be installed in the region to replace old incandescent lighting stock	0.04% 0.34 kt CO_2e	0.45% 3.4 kt CO_2e	0.6 Crore
		1000 street and public place lights to be replaced by LED lights by 2027	0.04% 0.23 kt CO_2e	0.3% 2.34 kt CO_2e	0.15 Crore
	Total of Energy Efficiency and Fuel Switching		0.09% 0.89 kt CO_2e	9.27% 71.5 kt CO_2e	2.75 Crore

Annexure 4 provides details on the indicative funding avenues for the estimated financial requirement for 2027.

Rajapalayam LPA Vision 2027

The following matrix provides low-hanging fruits and strategies to be implemented by 2027 that will enable Rajapalayam LPA to kick- start its endeavours for carbon neutrality while also building resilience. It may be noted that the comprehensive interventions to achieve the 2041 decarbonisation target are detailed in the respective sectoral sections as well as in the subsequent tables of this Chapter (Chapter-5).

Strategies	Target for 2027	Annual Mitigation potential (kt CO_2e) by 2027	Percentage Mitigation potential to net emission by 2027	Annual Mitigation potential (kt CO_2e) by 2041	Percentage Mitigation potential to net emission by 2041	Financial requirement (Cr) by 2027
1. **Municipal solid waste management** (Rajapalayam Municipality, Commissionerate of Municipal Administration, Rural Development and Panchayat Raj department, Tamil Nadu Pollution Control Board)						
Ensuring segregation at source through distribution of colour coded bins at households, commercial establishments, at key locations in the LPA such as markets, bus stops etc	100% segregation at source	2.4	0.33%	8	1.03%	4.5
Establishing waste transfer and processing stations for different waste streams - wet waste, recyclable waste, construction and demolition waste, hazardous and biomedical waste.	Transfer and processing facilities established in the LPA with 62 TPD capacity					2
Awareness campaigns to inform the residents of importance of waste segregation and to promote sustainable practices such as repair, reuse, recycle, reduce	Continued effort throughout the plan period					
EVs for municipal waste collection from households and waste transfer to treatment facilities	4 e-auto rickshaws for waste collection					0.4[28]
Setting up community based composting/ vermicomposting units at strategic locations	Facility to treat 21 TPD of wet waste and 22 TPD of dry waste					1.5
Total of Municipal Solid Waste Management		**2.4**	**0.33%**	**8**	**1.03%**	**8.4**

[28] Rs 1 lakh per e-auto rickshaw for municipal waste collection.

Strategies	Target for 2027	Annual Mitigation potential (kt CO_2e) by 2027	Percentage Mitigation potential to net emission by 2027	Annual Mitigation potential (kt CO_2e) by 2041	Percentage Mitigation potential to net emission by 2041	Financial requirement (Cr) by 2027
2. Plastic Waste Management						
Use of plastic waste for road construction	8% plastic mix in all new road construction activities in the LPA	NA				Additional cost of adding plastic - Rs 25,600/km road constructed (therefore 0.5; assuming 20 km of road is built)
Creating handicraft products out of non-recyclable plastic waste such as bags and baskets from multilayer plastic packaging Establishing units to locally produce alternatives to single use plastics such as plates, cutlery, bags made from alternative materials such as bamboo, leaves, recycled cloth etc and making these available for purchase	Establishing 10 units for creating handicraft products from non-recyclable plastic and alternatives to single use plastic and engaging local groups, women's groups, SHGs in manufacturing and marketing recyclable products within and outside the LPA.	NA				1
Setting up plastic waste processing plant to produce plastic pellets which can be recycled	Setting up of a shredder unit with capacity of 100 kg/hr					0.2

Strategies	Target for 2027	Annual Mitigation potential (kt CO_2e) by 2027	Percentage Mitigation potential to net emission by 2027	Annual Mitigation potential (kt CO_2e) by 2041	Percentage Mitigation potential to net emission by 2041	Financial requirement (Cr) by 2027
Total of Plastic Waste Management		**NA**		**NA**		**1.7**
3. Wastewater Management (Rajapalayam Municipality, Commissionerate of Municipal Administration, Rural Development and Panchayat Raj department, Tamil Nadu Water Supply and Drainage Board, Tamil Nadu Pollution Control Board)						
Set up adequate wastewater treatment facility	Ensure at least 60% of municipal area has UGD	44.5	6.15%	85.6	11%	101
Setting up of DEWATS along with simplified sewer system	3 DEWATS along with simplified sewer system for 3 high density villages namely Kadambankulam, Samusigapuram, Ramalingapuram					4.5
Setting up twin pit septic tanks and FSTP at village level	• Twin pit septic tanks for 35137 households of 10 revenue villages. • 1 FSTP across all the 10 Revenue Villages of Rajapalayam LPA					18
Total Wastewater Management		**44.5**	**6.15%**	**85.6**	**11%**	**123.5**
4. Green Spaces and Carbon sequestration (Environment and Climate Change department, Forest department, Rajapalayam Municipality, Commissionerate of Municipal Administration)						
Restoration and conservation of existing forest area and tree cover 1) Dedicated restoration and afforestation efforts for Sanjeevi Malai	111 ha (40% of Sanjeevi Malai Area) reforestation and afforestation By 2027 • Identification of plant species,planning, identification of	2.2	0.30%	33.1 ktCO₂e (cumulative) 1.84 ktCO₂e (per	0.24%	2

Strategies	Target for 2027	Annual Mitigation potential (kt CO_2e) by 2027	Percentage Mitigation potential to net emission by 2027	Annual Mitigation potential (kt CO_2e) by 2041	Percentage Mitigation potential to net emission by 2041	Financial requirement (Cr) by 2027
	species, laying the ground for the plantation, and acquiring plant species. ● The following year could be earmarked for plantations including tree guards, plant protectors, and putting in place a system for plant protection and maintenance of the plantation.			annum)		
2)Strengthening protection around existing reserved forest areas with additional measures of protection like: strengthening the fencing; eliminating encroachment; levying penalty on defaulters; etc.	422 ha (remaining area of the two reserved forests) By 2027 ● planning,identification of species, laying the ground for the plantation, and acquiring plant species. ● The following year could be earmarked for plantations including tree guards, plant protectors, and putting in place a system for plant protection and maintenance of the	1.1	0.15%	23 ktCO_2e (cumulative) 1.1 ktCO_2e (per annum)	0.14%	2

Strategies	Target for 2027	Annual Mitigation potential (kt CO_2e) by 2027	Percentage Mitigation potential to net emission by 2027	Annual Mitigation potential (kt CO_2e) by 2041	Percentage Mitigation potential to net emission by 2041	Financial requirement (Cr) by 2027
	plantation					
3)Creation of Eco-park at the base of Sanjeevi Malai on 44 acres of Bhoomidan lands	Completed and functional ecopark and educational programmes can commence	NA		NA		11
Increasing tree cover across the LPA in the area demarcated as non-urban use zone 1)Plantation of indigenous and high value trees with protection systems to increase tree / forest cover in industrial buffer zone, around the landfill and STP, along roads and pedestrian pathways 2)Plantation of appropriate tree species to restore the forest area and increase tree cover in the reserved forest buffer zone and around water bodies	Plantation in 1570 ha (50% of Non-urban areas+Urbanisable area+Aquifer recharge area) • The first two years will be planning, identification of species, laying the ground for the plantation, and acquiring plant species. The third and fourth years could be marked for the plantation of indigenous and high-value trees with tree guards in the dedicated buffer zones, around the water bodies, landfill and STP, along roads and pedestrian pathways.	43.2 ktCO_2e (per annum)	5.97%	777.15 ktCO_2e (cumulative) 43.2 ktCO_2e (per annum	5.55%	10
Beautification of the LPA by creating vertical gardens in strategic locations such as markets, under flyovers and	60 vertical gardens with a minimum area of 100 square feet/vertical garden	NA		NA		1.5

Strategies	Target for 2027	Annual Mitigation potential (kt CO_2e) by 2027	Percentage Mitigation potential to net emission by 2027	Annual Mitigation potential (kt CO_2e) by 2041	Percentage Mitigation potential to net emission by 2041	Financial requirement (Cr) by 2027
bridges, traffic intersections and roundabouts, road dividers, government buildings, institutional buildings etc						
Total of Green Spaces		**46.5 CO_2 kt/annum**	**6.42%**	**46.14 CO_2 kt/annum**	**5.93%**	**26.5**
5. Sustainable agriculture practices (Agriculture department, Horticulture department, Environment and Climate Change department, Tamil Nadu Green Energy Corporation Limited (TANGEDCO))						
Diversion of land under rice cultivation to other crops by promoting cultivation of millets which require less water and are drought resistant	5% area (~100 ha) shifted from rice cultivation by 2027	0.34	0.05%	2.5	0.32%	No direct cost involved
Adoption of practices such as mixed cropping and multi layer cropping to optimise/maximise agricultural output	285 Ha i.e 10% of non-rice cultivation area shifting to mixed and multi layer cropping	NA		NA		NA
Rice cultivation water regime shift from continuous flooding to multiple aeration combined with SRI (aggressive)	20% shift from continuous flooding to multiple aeration combined with SRI (aggressive)	1.30	0.18%	3.4	0.44%	1.22[29]
Use of organic fertiliser and compost in place of urea in agricultural production	30% agriculture area transitioned to organic fertiliser in aggressive scenario	0.25	0.03%	0.43	0.06%	5.68[30]
Capacity building programmes can be conducted through Krishi Vigyan Kendra for creating awareness on climate	Can be an ongoing initiative	NA		NA		NA

29 Rs 8000 per for SRI for 2026 and 2027 to promote multiple aeration

30 Rs 2500 per acre for each of the two seasons for 2026 and 2027 for transition to organic fertiliser

Strategies	Target for 2027	Annual Mitigation potential (kt CO_2e) by 2027	Percentage Mitigation potential to net emission by 2027	Annual Mitigation potential (kt CO_2e) by 2041	Percentage Mitigation potential to net emission by 2041	Financial requirement (Cr) by 2027
resilient practices						
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	10mini weather monitoring stations	NA		NA		0.2[31]
Feed inputs for livestock - Tamarin plus and Harit Dhara to reduce methane emissions from enteric fermentation	20% of cattle fed with Tamarin plus and Harit Dhara or similar improved cattle feed available in the market	2.367	0.33%	2.32	0.30%	1[32]
Building solar powered cattle sheds to enable dung collection at scale for utilising quality dung for use in biogas plants, organic fertiliser for crops etc - the solar capacity installed can be utilised in maintenance of the livestock as well as for other farm activities	500 cattle sheds with at least 1kW solar panels	1.1	0.15%	1.1	0.14%	10[33]
Total of Sustainable Agriculture Practices		**5.36**	**0.74%**	**9.75**	**1.25%**	**18**
Grand Total of all non-energy interventions (1+2+3+4+5)		**98.76**	**13.64%**	**149.5**	**19.20%**	**178.1**

31 Rs 2 lakh per weather monitoring station
32 Rs 6 per day per cattle for 20% of cattle population of 2025, 2026 and 2027
33 Rs 2 lakh per shed to establish solar powered cattle sheds.

Energy Sector Interventions

Strategies	Target for 2027	Annual Mitigation potential (kt CO2e) by 2027	Percentage Mitigation potential to net emission by 2027	Annual Mitigation potential (kt CO2e) by 2041	Percentage Mitigation potential to net emission by 2041	Financial requirement (Cr) by 2027
(A) Harnessing Renewable Energy Potential						
Installing Solar rooftop across residential home under PM Suryaghar Muft Bijli Yojana and prioritizing rooftop solar on all government building (MNRE mandate for 2025)	To achieve 40 MW of additional rooftop capacity	46.6	6.44%	176	22.61%	220
Installation of solar pumps to replace existing diesel pumps in the LPA under PM KUSUM scheme (Component B).	To add 300 number of agricultural solar pumps (total diesel pumps in LPA are ~ 3000)	1.4	0.19%	3.64	0.41%	7.5
Creating additional Renewable Energy generation sources in the LPA region				287	37%	
Decarbonising Electricity consumption by harnessing RE in the industries				38	6%	
(B) Road Transport Electrification						
Addition of electric 2 Wheelers, 3 Wheelers and Electric buses on priority	A total of 6500 2-wheelers EV to be introduced till 2027 (target of 65000 by 2041)	1.79	0.25%	17.93	2.31%	58.5
	Total of 25 E-buses to be introduced in the	0.23		4.2		30

	public transport segment		0.03%		0.54%	
	A total of 250 passenger 3 wheelers EV and 250 commercial 3 wheelers EV to introduced till 2027	0.73	0.1%	6.56	0.84%	15
Shift to private electric mobility	A total of 4500 4-wheelers to be introduced till 2041			1.983	0.26%	
(C) Energy Efficiency and Fuel Switching						
Residential households to shift to electric cookstoves to reduce reliance on LPG and biomass	5000 electric cook stoves to replace conventional LPG gas stoves and biomass usage	0.32	0.05%	1.1	0.15%	2
Annual Electricity saving potential as per industrial energy efficiency interventions				30.66	4%	
Adoption of super energy efficient appliances in households (Fans, Space Cooling Units, Refrigerators)				34	4%	
Adoption of LED lighting to replace conventional source (incandescent, CFL) of lighting sources	60000 LED bulbs to be installed in the region to replace old incandescent lighting stock	0.34	0.05%	3.4	0.45%	0.6
	1000 street and public place lights to be replaced by LED lights by 2027	0.23	0.03%	2.34	0.3%	0.15
Total of A, B, C		**51.7**	**7.12%**	**616**	**81%**	**334**

Financial Requirements and Actions for all Proposed Interventions

A detailed list of interventions for both the energy and other sectors along with the estimated budgets and estimated GHG emission reduction potentials are provided below.

Further, an additional document on year-on-year activities pertaining to all of the suggested interventions along with estimated year-on-year budgets is also present in the report.

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 (ktCO$_2$e)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
A	**Harnessing Renewable Energy Potential**					
	Harnessing rooftop solar potential in the region	Industries to install rooftop solar at their roof space (Total Potential-82 MW)	To achieve 60 MW of industrial rooftop capacity	52.71	330	National Solar Mission/Tamil Nadu Solar Energy Policy
		Residential owners to install the rooftop solar plant (Total Potential-199 MW)	To achieve 120 MW of residential rooftop capacity	109.05	660	
		Rooftop installation over Commercial spaces (Total Potential-28 MW)	To achieve 20 MW of commercial rooftop capacity	18.18	110	
	Use of solar pump in the region	Currently LPA area has a total installed capacity of 15,377 HP with approximately 3000 connections	1000 solar pumps (5HP) to be installed for irrigation	3.64	25	PM-KUSUM
	Construction of biogas plants in the region	For utilising cow dung, the region could potentially install a biogas plant of approximately 3500 m3/day capacity. Proposing 1750 m3/day biogas plant	Installation of 1750 m3/day biogas plant	1.6	3.5	Gobardhan and Satat Scheme
	Creating additional renewable energy generation sources in the LPA region	To construct and Install Ground Mounted Solar in the LPA region (Total Potential-368 MW)	To install 300 MW (80% of potential) of Ground mounted solar capacity	287	1650	Tamil Nadu Solar Energy Policy
		Floating Solar PV Capacity addition (Total Potential-263 to 395 MW)	Not considering in the main intervention but could be a	N/A	N/A	

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 ($ktCO_2e$)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
			potential source for carbon abatement in future			
	Decarbonising electricity consumption by harnessing RE	HT and LT Industries to procure the electricity of Non-fossil sources through open access or captive route of approx 350 MW	50 MW PPA from Non-fossil sources (outside LPA boundary) over an above the proposed ground mounted intervention	38	275	Green Energy Open Access Rules / Tamil Nadu solar energy policy
	Sub-total of possible financial implications for harnessing renewable energy potential				**3053.5**	
B	**Clean and Sustainable Practices**					
	Shift to private electric mobility	Share of EV in 2W in new sale to increase upto 80% by 2041	A total of 65000 2-wheelers to be introduced till 2041	17.93	585	Tamil Nadu EV policy, FAME and other fiscal measures of the state and central government
		Share of EV in 4W in new sale to increase upto 70% by 2041	A total of 4500 4-wheelers to be introduced till 2041	1.983	540	
	Electrify the public and heavy transport vehicles (3 wheelers, buses and trucks)	Share of EV in Public transport (Buses) to increase upto 40%	Total of 450 E-buses to be introduced in the public transport segment till 2041	4.136	540	
		Share of EV in Public transport (3 wheelers)	A total of 2500 passenger 3 wheelers and 2000 commercial 3 wheelers to introduced till 2041	6.56	135	
		EV trucks in heavy transport vehicle segment (5% of the total truck stock in the region)	Total of 100 E-trucks to be introduced in the public transport segment till 2041	1.09	200	
	Creation of EV charging infrastructure	creating 28 charging station	13 charging stations on existing petrol pumps and 15 charging stations in the	N/A	13.44	

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 ($ktCO_2e$)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
			optimal positions in the region including bus depots			
	Cooking fuel switching (Biomass and LPG to electricity)	Residential households to shift to electric cookstoves	17000 electric cookstoves (two plate) to be use in place of conventional LPG gas stoves by 2041	1.07	13	Go-electric campaign, NECP
	Energy efficiency improvements	Annual Electricity saving potential as per energy audit reports of industries	Saving of 7% in industrial consumption through various interventions from enenrgy audit studies	30.66	44	National Mission for Enhanced Energy Efficiency (NMEEE)
		Increasing share of energy efficient ACs in new AC sales	A total 11000 3/5 star AC is to be used for cooling purpose	12.78	55	
		Increasing share of energy efficient refrigeration units in new sales	A total ~1 lakh 3/5 star refrigeration units are to be used for cooling purposes	11.6	250	
		Residential households to adopt LED bulbs to replace incandescent bulbs	6 lakh LED bulbs to be installed in the region to replace old lighting stock	3.36	6	NMEEE, UJALA
		inefficient public building and street lights to be replaced with LED lights	10,000 street and public place lights to be replaced by year 2041	2.34	2	
		Adoption of Other Five-star appliances, BLDC fan	2.15 lakh fans to be replaced with energy-efficient fans	2.1	58	Energy Efficiency Financing Platform
	Sub-total of possible financial implications for clean and sustainable practices				**2440**	

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 ($ktCO_2e$)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
C	**Waste Management in the Region**					
	Municipal waste management	Ensuring segregation at source through distribution of colour coded bins at households, commercial establishments, at key locations in the LPA such as markets, bus stops etc	100% segregation at source	8	4.5	Soild Waste Management Rules, 2016; Plastic Waste Management Rules, 2016
		Establishing waste transfer and processing stations for different waste streams - wet waste, recyclable waste, construction and demolition waste, hazardous and biomedical waste.	Transfer and processing facilities established in the LPA with 62 TPD capacity		2	
		Awaress campaigns to inform the residents of importance of waste segregation and to promote sustainable practices such as repair, reuse, recycle, reduce	continued effort throughout the plan period			
		EVs for municipal waste collection from households and waste transfer to treatment facilities	EV for the waste collection			
	Wet waste composting	Setting up community based composting/vermi composting units at strategic locations	Facility to treat 21 TPD of wet waste and 22 TPD of dry waste		1.5	Swachh Bharat Abhiyan, National Mission for Sustainable Agriculture

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 ($ktCO_2e$)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
		Establishing a value chain for utilisation, marketing and sale of compost generated from the composting units	Engaging local groups, women's groups, SHGs and FPOs in manufacturing and marketing compost products within and outside the LPA.		NA	
	Plastic waste management	Use of plastic waste for road construction	8% plastic mix in all new road construction activities in the LPA	NA	Additional cost of adding plastic - Rs 25,600/km road constructed	
		Creating handicraft products out of non-recyclable plastic waste such as bags and baskets from multilayer plastic packaging	Establishing 10 units for creating handicraft products from non-recyclable plastic and alternatives to single use plastic and engaging local groups, women's groups, SHGs in manufacturing and marketing recyclable products within and outside the LPA.	NA	10 lakhs for establishing units, training and manufacturing	National Handicrafts Development Program
		Establishing units to locally produce alternatives to single use plastics such as plates, cutlery, bags made from alternative materials such as bamboo, leaves, recycled cloth etc and making these available for purchase				
		Awareness campaign to reduce Single Use Plastics and promote use of sustainable products	Can be an ongoing initiative			

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 ($ktCO_2e$)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
		Setting up plastic waste processing plant to produce plastic pellets which can be recycled	Setting up of a shredder unit with capacity of 100 kg/hr		0.20	
	Wastewater management	Set up adequate wastewater treatment plants	Ensure at least 100% of municipal area has UGD	85.6	170	
		Setting up of DEWATS along with simplified sewer system	3 DEWATS along with simplified sewer system for 3 high density villages namely Kadambankulam, Samusigapuram, Ramalingapuram		4.5	
		Setting up twin pit septic tanks and FSTP at village level	• Twin pit septic tanks for 35137 households of 10 revenue villages. • 1 FSTP across all the 10 Revenue Villages of Rajapalayam LPA		18	
	Scope of waste to energy	Since solid waste generated in LPA region is very limited and may not suffice for scale level waste to energy plants, the solid waste utilisation could be considered while preparing waste-to-energy strategies for the entire Virudhunagar district.			N/A	N/A
	Sub-total of possible financial implications for Waste Management				**200.8**	

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 ($ktCO_2e$)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
D	**Green Spaces and Carbon Sequestration**					
	Restoration and conservation of existing forest area and tree cover	Dedicated restoration and afforestation efforts for Sanjeevi Malai	111 ha (40% of Sanjeevi Malai Area) reforestation and afforestation In the subsequent years, continuous monitoring and maintenance of the plantations need to be undertaken	33.1 $ktCO_2e$ (cumulative) 1.84 $ktCO_2e$ (per annum)	2	
		Creation of Eco-park at the base of Sanjeevi Malai on 44 acres of Bhoomidan lands.	Design and implementation of the eco park, that not only promotes the conservation of biodiversity and carbon sequestration plantations (both on Sanjeevi malai and in the LPA) but it will also showcase all of the latest technologies for alternative energy as well as energy efficiency.		11	
		Strengthening protection around existing reserved forest areas with additional measures of protection like: strengthening the fencing; eliminating encroachment; levying penalty on defaulters; etc. as given in the document	422 ha (remaining area of the two reserved forests) In the subsequent years, continuous monitoring and maintenance of the plantations need to be undertaken	23 $ktCO_2e$ (cumulative) 1.1 $ktCO_2e$ (per annum)	2	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

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 ($ktCO_2e$)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
	Increasing tree cover across the LPA in the area demarcated as non-urban use zone	Plantation of appropriate tree species to restore the forest area and increase tree cover in the reserved forest buffer zone and around water bodies	Plantation in 1570 ha (50% of Non-urban areas+Urbanisable area+Aquifer recharge area)	777.15 $ktCO_2e$ (cumulative) 43.2 $ktCO_2e$ (per annum)	10	Planning Authority Fund (State CAMPA fund); Jal Jeevan Mission
		Plantation of indigenous and high value trees with tree guards in industrial buffer zone, around the landfill and STP, along roads and pedestrian pathways	In the subsequent years, monitoring and maintenance of the plantations need to be undertaken			
	Plantation as green walls, vertical frames, vertical gardens	Beautification of the LPA by creating vertical gardens in strategic locations such as markets, under flyovers and bridges, traffic intersections and roundabouts, road dividers, government buildings, institutional buildings etc	60 vertical gardens with a minimum area of 100 square feet/vertical garden	NA (because ornamental plants have very short life spans)	1.5	
	Sub-total of possible financial implications for green spaces and carbon sequestration				**26.5**	
E	**Behavioural Interventions**					
	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.	6.712	70	

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 ($ktCO_2e$)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
	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 the masterplan	NA	50	
	Automation of lighting in commercial segment	Installation of lighting sensors in commercial buildings	2162 (20% of total commercial buildings) building to use lighting sensors	1.365	0.2162	
	Energy saving in space cooling	Reduction in Air condition electricity consumption by keeping temperature setting to 26 C	Temperature setting to 26 degree C	6.84	NA	
	Efficient driving behaviour	Improvement in ICE Vehicle Efficiency by 0.5% annually	Majority ICE 2W and 4W in the LPA show efficient driving behaviour	9.04	NA	
	Waste	Awareness campaigns to inform the residents of importance of waste segregation and to promote sustainable practices such as repair, reuse, recycle, reduce				Swachh Bharat Mission
	Sub-total of possible financial implications for behavioural interventions				**120.22**	

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 ($ktCO_2e$)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
F	**Sustainable Agriculture Practices**					
	Promoting crop diversification	Diversion of land under rice cultivation to other crops by promoting cultivation of millets which require less water and are drought resistant	310 ha i.e. 30% area shifted from rice cultivation	2.5	No direct cost involved	National Mission for Sustainable Agriculture
		Adoption of practices such as mixed cropping and multi layer cropping to optimise/maximise agricultural output	1422.7 Ha i.e 50% of non-rice cultivation area shifting to mixed and multi layer cropping	NA	NA	National Mission for Sustainable Agriculture
	Promote modern cultivation techniques to optimise agricultural inputs and maximise outputs	Adopting techniques like System for Rice Intensification (SRI) and Direct Seeded Rice for rice cultivation	100% shift from continuous flooding to multiple aeration combined with SRI (aggressive)	3.4	21.5	National Mission for Sustainable Agriculture
		Use of organic fertiliser and compost in place of urea in agricultural production	100% agriculture area transitioned to organic fertiliser in aggressive scenario	0.43	86	National Mission for Sustainable Agriculture, Paramparik Krishi Vikas Yojana
		Capacity building programmes can be conducted through Krishi Vigyan Kendra for creating awareness on climate resilient practices	Can be an ongoing initiative	NA	NA	Paramparik Krishi Vikas Yojana

Sr No	Key Intervention	Activity	Targets for Year 2041	Approximate Annual Mitigation Potential in 2041 ($ktCO_2e$)	Financial implications till 2041 (in Rs Cr)	Policies / Fiscal Measures by State and Central Government
		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	10 mini weather monitoring stations	NA	0.2	
	Livestock management	Feed inputs for livestock - Tamarin plus and Harit Dhara to reduce methane emissions from enteric fermentation	100% of livestock fed with Tamarin plus and Harit Dhara or similar improved cattle feed available in the market	2.32	58.12	
		Building solar powered cattle sheds to enable dung collection at scale for utilising quality dung for use in biogas plants, organic fertiliser for crops etc - the solar capacity installed can be utilised in maintenance of the livestock as well as for other farm activities	1000 cattle sheds with atleast 1kW solar panels constructed by 2041 in the following manner: (100 sheds constructed by 2025, 300 sheds constructed by 2030, 300 sheds constructed by 2035, and 300 sheds constructed by 2041)	1.1	20	Gobar Dhan Scheme
	Sub-total of possible financial implications for sustainable agriculture practices				**185.82**	

Year-on-Year Interventions - Energy Sectors

	Interventions	Scheme/ Policy		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
A	**Harnessing Renewable Energy Potential**																				
																					Financial Implication in Rs Cr
1	To achieve 60 MW of industrial rooftop capacity	NSM/ TNSEP	YOY Target	0	0	0	0	12	12	12	12	12	0	0	0	0	0	0	0	0	0
			Financial Implication	0	0	0	0	66	66	66	66	66	0	0	0	0	0	0	0	0	0
2	To achieve 120 MW of residential rooftop capacity	NSM/ TNSEP	YOY Target	10	15	15	10	10	10	10	15	15	10	0	0	0	0	0	0	0	0
			Financial Implication	55	82.5	82.5	55	55	55	55	82.5	82.5	55	0	0	0	0	0	0	0	0
3	To achieve 20 MW of commercial rooftop capacity	NSM/ TNSEP	YOY Target	0	0	0	0	5	5	5	5	0	0	0	0	0	0	0	0	0	0
			Financial Implication	0	0	0	0	27.5	27.5	27.5	27.5	0	0	0	0	0	0	0	0	0	0
4	1000 solar pumps (5HP) to be installed for irrigation	PMKUSUM/ TNSEP	YOY Target	100	100	100	100	100	100	100	100	100	100	0	0	0	0	0	0	0	0
			Financial Implication	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0	0	0	0	0	0	0	0
5	Installation of 1750 m3/day biogas plant	Gobardhan and SATAT Scheme	YOY Target	0	0	0	350	350	350	350	350	0	0	0	0	0	0	0	0	0	0
			Financial Implication	0	0	0	0.7	0.7	0.7	0.7	0.7	0	0	0	0	0	0	0	0	0	0
6	To achieve additional 50 MW of Ground mounted solar capacity	NSM/ TNSEP	YOY Target	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	25
			Financial Implication	0	0	0	0	0	0	0	137.5	0	0	0	0	0	0	0	0	0	137.5
7	PPA from non-fossil sources 300 MW	GEOAR/ TNSEP	YOY Target	0	0	0	10	10	10	20	20	20	20	20	20	20	20	20	30	30	30
			Financial Implication	0	0	0	55	55	55	110	110	110	110	110	110	110	110	110	165	165	165
	Financial Implication Sub Total (A) in Rs Cr			57.5	85	85	113.2	206.7	206.7	261.7	426.7	261	167.5	110	110	110	110	110	165	165	302.5

	Interventions	Scheme/ Policy		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
B	**Clean and Sustainable Practices**																				
																					Financial Implication in Rs Cr
1	A total of 65000 2-wheelers to be introduced till 2041	TNEVP, FAME and other fiscal measures of the State and Central Govt	YOY Target	1,500	2,500	2,500	3,000	3,500	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
			Financial Implication	14	23	23	27	32	36	36	36	36	36	36	36	36	36	36	36	36	36
2	A total of 4500 4-wheelers to be introduced till 2041		YOY Target	0	0	0	100	150	160	200	200	250	275	300	340	350	370	401	439	478	487
			Financial Implication	0	0	0	12	18	19	24	24	30	33	36	41	42	44	48	53	57	58
3	Total of 450 E-buses to be introduced in the public transport segment till 2041		YOY Target	4	10	11	12	13	15	20	20	23	25	27	30	33	36	39	41	44	47
			Financial Implication	5	12	13	14	16	18	24	24	28	30	32	36	40	43	47	49	53	56
4	A total of 2500 passenger 3 wheelers and 2000 commercial 3 wheelers to introduced till 2041		YOY Target	100	200	200	200	200	200	200	200	200	200	200	200	200	300	400	400	450	450
			Financial Implication	3	6	6	6	6	6	6	6	6	6	6	6	6	9	12	12	14	14
5	Total of 100 E-trucks to be introduced in the public transport segment till 2041		YOY Target	0	0	0	4	4	4	5	5	5	6	7	7	8	8	8	9	10	10
			Financial Implication	0	0	0	8	8	8	10	10	10	12	14	14	16	16	16	18	20	20

	Interventions	Scheme/ Policy		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
6	13 charging stations on existing petrol pumps and 15 charging stations in the optimal positions in the region including bus depots		YOY Target	0	0	0	2	5	5	5	5	6	0	0	0	0	0	0	0	0	0
			Financial Implication	0	0	0	1.0	2.4	2.4	2.4	2.4	2.9	0	0	0	0	0	0	0	0	0
7	17000 electric cookstoves (two plates) to be used in place of conventional LPG gas stoves by 2041	Go-electric campaign, NECP	YOY Target	1,000	2,000	2,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0	0	0
			Financial Implication	0.8	1.5	1.5	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.0	0.0	0.0
8	Saving of 7% in industrial consumption through various interventions from energy audit studies	NMEEE	YOY Target	0	0	0	0	0	0	0	7(%)	0	0	0	0	0	0	0	0	0	0
			Financial Implication	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0	0
9	A total 11000 3/5 star AC is to be used for cooling purpose	NMEEE	YOY Target	0	0	0	500	600	600	600	600	650	650	700	750	750	800	900	900	1000	1000
			Financial Implication	0.0	0.0	0.0	2.5	3.0	3.0	3.0	3.0	3.3	3.3	3.5	3.8	3.8	4.0	4.5	4.5	5.0	5.0
10	A total ~1 lakh 3/5 star refrigeration units are to be used for cooling purposes	NMEEE	YOY Target	0	0	0	5,000	5,000	5,000	5,000	5,000	7,000	7,000	7,000	7,000	7,000	8,000	8,000	8,000	8,000	8,000
			Financial Implication	0	0	0	12.5	12.5	12.5	12.5	12.5	17.5	17.5	17.5	17.5	17.5	20	20	20	20	20

	Interventions	Scheme/ Policy		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
11	6 lakh LED bulbs to be installed in the region to replace old lighting stock	NMEEE, UJALA	YOY Target	20,000	20,000	20,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	40,000	40,000	40,000	50,000	50,000	50,000
			Financial Implication	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5
12	10,000 street and public place lights to be replaced by year 2041	NMEEE, UJALA	YOY Target	0	500	500	500	500	500	500	500	600	600	600	600	600	700	700	700	700	700
			Financial Implication	0.00	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.11	0.11	0.11	0.11	0.11
13	2.15 lakh fans to be replaced with energy-efficient fans	NMEEE, UJALA, EEFP	YOY Target	0	0	0	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	15,000	20,000	20,000	20,000	20,000	20,000	20,000
			Financial Implication	0	0	0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	4.05	5.4	5.4	5.4	5.4	5.4	5.4
	Financial Implication Sub Total (B) in Rs Cr			22	42	43	87	101	109	122	166	137	142	149	159	167	179	190	198	211	215
C	**Total Year-on-year Energy Sector Financial Implication (Rs Cr) (A+B)**			80	127	128	200	308	316	383	592	398	309	259	269	277	289	300	363	376	518
D	**Total Financial Implication (Rs Cr) till 2041**			**5,494**																	

Note: Years represent financial years, e g: FY2024-25 is represented as 2025

Year-on-Year Interventions - Other Sectors

Green Spaces and Carbon Sequestration

1. Key Intervention: Restoration and conservation of existing forest and tree cover especially the Sanjeevi Malai restoration.

Target set for 2041: 111 ha (40 percent of Sanjeevi Malai Area) for dedicated restoration + protection 422 ha (remaining area of the two reserved forests).

Proposed activities and year-wise plan

- The first 6-8 months will be planning, identification of species, laying the ground for the plantation, and acquiring plant species.
- The following year could be earmarked for plantations including tree guards, plant protectors, and putting in place a system for plant protection and maintenance of the plantation.
- The carbon sequestration would commence immediately and progressively increase until 2041.
- The estimated carbon sequestration at the end of 2041 for the above two targets is as follows:
  a. Dedicated restoration of Sanjeevi Malai selected area: 33.1 $KtCO_2e$ (cumulative) or 1.84 $ktCO_2e$ (per annum).
  b. Protection of the remaining reserved forest: 23 $ktCO_2e$ (cumulative) and 1.14 $ktCO_2e$ (per annum).

2. Key Intervention: Creation of Eco-park at the base of Sanjeevi Malai on 44 acres of Bhoomidan lands.

Target set for 2041: Design and implementation of the eco park, that not only promotes the conservation of biodiversity and carbon sequestration plantations (both on Sanjeevi Malai and in the LPA) but it will also showcase all of the latest technologies for alternative energy as well as energy efficiency. It will, in fact, become the Carbon Neutral Hub for Rajapalayam, which will serve an immense role in the education for behavioural change required in the highest level pathway proposed as Aggressive Behavioural Change Scenario (ABS).

Proposed activities and year-wise plan

- The first six months will be for planning and designing the park, building on the conceptual plans already prepared by local experts.
- By the end of year two the park will be completed and functional.
- From year one, educational programs will already commence and in the following years the programs will scale up to serve 200 school visits per year, as well as 100 local community groups per year.
- The centre will also implement and showcase economic models of tree plantation specifically adapted to the local conditions of the Rajapalayam area, and will run these plantations in conjunction with local landowners in a variety of different soil types and geographical locations.
- The center serves as the hub and resource center for local conservation groups that are active in the preservation of biodiversity, water resources and solid waste management.

3. Key Intervention: Plantations in the city area.

Target set for 2041: 1570 ha (50 percent of (Non-urban Area + Urbanisable Area + Aquifer Recharge Area)*.

Proposed activities and year-wise plan

- The first two years will be planning, identification of species, laying the ground for the plantation, and acquiring plant species.
- The third and fourth years could be marked for the plantation of indigenous and high-value trees with tree guards in the dedicated buffer zones, around the water bodies, landfill and STP, along roads and pedestrian pathways.
- The carbon sequestration would start from the third year (2025) and progressively increase until 2041.
- The estimated carbon sequestration, through this plan is estimated to be around 777.15 $KtCO_2e$ (cumulative by 2041) 43.2 $KtCO_2e$ (per annum).

4. Key Intervention: Plantation as green walls, vertical frames and vertical gardens.

Target set for 2041: 60 vertical gardens with a minimum area of 100 square feet/vertical garden.

Proposed activities and year-wise plan:

- The first two years will be planning, and finding strategic locations such as markets, under flyovers and bridges, traffic intersections and roundabouts, road dividers, government buildings, institutional buildings etc.
- Subsequent years could be dedicated to creating vertical gardens in a phased manner.
- Maintenance, regeneration, replantation for the remaining years and scaled-up at suitable locations.

Sustainable Agricultural Practices

1. Key Intervention: Promoting crop diversification.

Target set for 2041

a. 310 Ha i.e. 30 percent area shifted from rice cultivation.
b. 1422.7 ha i.e. 50 percent of non-rice cultivation area shifting to mixed and multi-layer cropping.

Proposed activities and year-wise plan

- The initial 3-5 years will be dedicated to generating awareness on the significance of sustainable and climate-friendly agriculture practices through specific Information Education Communication (IEC) activities.
- Following this, from the sixth year onwards a few pilot plots can be used for sustainable agricultural practices like multilayer cropping, zero tillage, mixed cropping etc.
- Methods that have been successful over the years can be scaled up
- In the later part of the proposed period between 2021-2041, i.e. starting from 2032 large farmers can pilot some area of their agricultural land to grow crops other than rice like

* The green spaces around the water bodies will act as recreational spaces for the locals. Additionally, the co-benefits of the plantations/green spaces will lead to water recharge, soil conservation, reduction in urban heat island effect and enhancing biodiversity.

crops that require less water (millets).

- This can be scaled up and farmers who have been successful can lead to train other farmers.
- Overall, even if 30 percent of the area under rice is shifted, 2.5 KtCO_2e can be mitigated in 2041.

2. Key Intervention: Adopting techniques like System for Rice Intensification (SRI) and Direct Seeded Rice for rice cultivation.

Target set for 2041: 100 percent shift in rice cultivation water regime from continuous flooding to multiple aeration combined with System of Rice Intensification (SRI).

Proposed activities and year-wise plan

- The initial two years will be dedicated for generating awareness on the economic benefits and cost of cultivation of SRI over the prevalent method of rice cultivation through specific IEC activities.
- From third year onwards, a certain percentage of large-scale farmers can be piloted for shifting to multiple aeration with SRI.
- On successful completion, these farmers can lead to train the remaining farmers on benefits in making this shift.
- A 100 percent shift in the water regime can be achieved gradually (40 percent by 2030, 60 percent by 2035, and 100 percent by 2041).
- A 100 percent shift in water regime to multiple aeration systems combined with SRI programme has the potential to mitigate 3.4 ktCO_2e in 2041.

3. Key Intervention: Use of organic fertiliser and compost in place of urea in agricultural production.

Target set for 2041: 100 percent agriculture area uses organic fertiliser.

Proposed activities and year-wise plan

- The initial 3-5 years will be dedicated to generate awareness on using organic fertilisers through specific IEC activities and to conduct evaluation of the soil structure, nutrient levels, organic matter content, and erosion level. Further, study and eliminate factors that are limiting the access of farmers like capital, labour, market access, among others.
- In the subsequent years, organic fertiliser companies could be encouraged to provide rebates for accelerated adoption of organic fertilisers.
- Farmers can be connected with entities that procure organic produce directly from farmers.
- Shift to organic fertilisers can be achieved gradually (40 percent by 2030, 60 percent by 2035 and 100 percent by 2041).
- A 100 percent shift in chemical fertilisers to organic fertilisers has a potential to mitigate 0.43 KtCO_2e in 2041.

4. Key Intervention: Improved livestock management techniques.

Target set for 2041

a. Having at least 1000 cattle sheds powered with a minimum of 1 kW solar panel.

b. 100 percent of cattle to be fed with Tamarin plus and Harit Dhara or similar improved cattle feed available in the market.

Proposed activities and year-wise plan:

Solar-powered cattle sheds:

- Awareness generation activities on installing solar rooftops on cattle sheds to meet energy needs for livestock maintenance and related farm activities.
- In the years leading up to 2041, uptake of solar in cattle sheds can be targeted in phases
  a. 100 cattle shed with 1 kW and above by 2025
  b. Additional 300 cattle sheds to be covered by 2030
  c. Another 300 by 2035
  d. And 300 more sheds (a total of 1000) by 2041
- 1000 cattle sheds powered with solar energy have the potential to mitigate 1.1 ktCO_2e in 2041.

Feed additives to reduce livestock emissions:

- In the initial areas IEC activities can be organised to generate awareness on the benefits of feed additives in enhancing cattle yield and reducing livestock emissions.
- Organise exposure visits for pastoral community/farmers to other villages/districts that practice adding feed additives to fodder.
- Organise skits, workshops and talks by local agriculture/animal husbandry institutes/ universities/experts.
- Proposed intervention to be piloted for 50 percent of cows of selected farmers (large holding farmers). Feed like Tamarin plus and Harit Dhara are to be added to fodder in a phased manner.
- Based on results, addition of feed additives can be modified.
- The intervention can be scaled up to cover 100 percent cattle of the large farmers/ pastoral community.
- The intervention can be scaled up to other farmers to cover 100 percent cattle of the Rajapalayam LPA.
- This intervention has the potential to mitigate 2.32 ktCO_2e.

5. Key Intervention: Installing mini weather-monitoring stations to enable.

Target set for 2041: Install 10 mini weather-monitoring stations across the LPA.

Proposed activities and year-wise plan

- The entire intervention needs to be undertaken in collaboration with local technical institutions, agricultural universities, agriculture department and Krishi Vigyan Kendra (KVK).
- Farmers can be educated on how to use information from weather services and the likely benefits of making informed farming choices based on temperature and rainfall-related updates received from mini weather-monitoring stations.

- Pilot scenario: For the initial two years, identify medium-sized agricultural plots where farming activities could be carried out based on the inputs from one mini weather-monitoring station (monitoring wind, temperature, humidity, rainfall etc) installed at a suitable location in the vicinity.
- The experience of the farmer and results associated with the use of inputs from mini weather-monitoring stations could be evaluated and shared in the community to promote acceptance of this technology.
- Installation of nine similar stations at strategic and evenly spaced out locations across the LPA. Wherein, at least three new monitoring stations are installed every five years.
- The data generated from these weather stations will help generate long-term weather and rainfall data for the region and could be an important resource for future planning of development activities in the LPA.

Solid Waste Management

1. Key Intervention: Setting up community-based composting/vermicomposting units at strategic locations.

Target set for 2041: Additional wet waste treatment capacity of 21 TPD and dry waste treatment capacity of 22 TPD.

Proposed activities

- Each village with more than 10,000 population should have a minimum of one micro composting center, while the municipal area of Rajapalayam should have three such centers.
- There is a need to create dedicated awareness campaigns about waste segregation at the household level in both municipal and non-municipal areas. Emphasis should also be placed on capacity building and providing training on operating composting centers.
- An additional one to two years may be dedicated to constructing and establishing composting centers, with several months allocated for training on packaging and marketing.
- Leading up to 2041, initiatives should focus on promoting waste-to-energy plants and encouraging the recycling and reuse of dry waste.

2. Key Intervention: Plastic Waste Management.

Target set for 2041

a. Setting up of a shredder unit with capacity of 100 kg/hr.
b. Establishing a minimum of 10 units for creating handicraft products from non-recyclable plastic and alternatives to single use plastic.

Proposed activities

- Increase the IEC activities around minimised consumption of single use plastics and encourage promotion of sustainable alternatives primarily, in the food and packaging space. Periodic stocktake at the waste collection centres on the plastic waste accumulation would provide feedback on the continued need for having IEC activities.
- Strengthen the waste management systems by ensuring maximum separation of wet and dry waste. Similarly, through the use of technology/improved systems separation of plastics based on grade/quality could be streamlined.
- Adequate routing mechanisms could be established for transferring the recyclable plastic

waste to the recycling value chain, until a plastic shredder unit is installed in the area.

- By 2041, the town could establish a shredder unit with a capacity of 100 kg/hr, attracting plastic waste from all surrounding areas. The unit can also act as a serving unit for plastic pellets and integrate with the recycling value chain that enters the clothing and footwear industry. This initiative must be implemented through appropriate engagement of local groups, women's groups, and SHGs.
- Promote and incentivise the setting up of handicraft production units that either use shredded plastic as feed or manufacture alternatives to single use plastics (tax holidays, tax exemptions etc).

Wastewater Treatment

The following interventions have the potential to mitigate 85.6 ktCO2e (for treating ~34 MLD of wastewater that is expected to be generated in 2041).

1. Key Interventions:

a. 3 DEWATS along with simplified sewer system for 3 high density villages namely Kadambankulam, Samusigapuram,Ramalingapuram
b. Twin pit septic tanks for 35137 households of 10 revenue villages.
c. 1 FSTP across all the 10 Revenue Villages of Rajapalayam LPA
d. Mandate appropriate town planning, including the UGD connections for the layout to be developed in the future.

Target for 2041: 100% for urban area, UGD, 3 DEWAT and 1 FSTP

2. Key Intervention: Increase household connections to underground drainage.

Target for 2041: 100 percent households to be connected with UGD

Proposed activities and year-wise plan

- Once a sufficient number of households are identified as a group, a suitable piece of land adjoining their houses/dwelling must be identified and designed in the first two years. This can impose an additional cost of 170 crores.
- Awareness generation and strategic behaviour change communication to ensure that sanitation as an issue is mainstreamed with the general public at large and should cover issues of open defecation, prevention of manual scavenging, hygiene practices, proper use and maintenance of toilet facilities (household, community or otherwise), etc., and its related health and environmental consequences.
- It is estimated that about 20 percent of the urban households in cities, who are currently practicing open defecation are likely to use community toilets as a solution due to land and space constraints in constructing individual household latrine, therefore community toilets must be constructed with an adequate number of seats and proper maintenance by 2041. The tentative basic cost for community toilets is Rs. 65,000/- per seat and public toilets is Rs. 75,000/- per seat.

6. Conclusion and the Way Forward

In order to ensure the effective implementation of the proposed actions/activities detailed out in the plan, the following process would have to be put in place:

a. A concerted awareness generation and outreach strategy and implementation plan to ensure that all stakeholders are aware of their role in making Rajapalayam truly a model climate-smart and carbon-neutral town by 2041.
b. Outreach to various line departments and agencies of the Government of Tamil Nadu on the plan, in order to ensure that the various programmes and schemes of the national government and the Government of Tamil Nadu can be leveraged for gap funding.
c. Funding gap analysis has to be undertaken to augment resources that may not be available through ongoing Government Schemes.
d. In the medium to long term, certain policies of the Government of Tamil Nadu may have to be tweaked, for instance, policy related to incentivising the installation of solar rooftop particularly on industrial building rooftops.
e. While for some sectors, the plan has been elaborated, a detailed project report may have to be prepared to ensure the initiation of projects suggested in the plan.
f. The plan was prepared in line with the 'Rajapalayam Master Plan - 2041' which was recently approved by the Department of Housing and Urban Development, Government of Tamil Nadu, and based on data that was collected and collated for the development of the Rajapalayam Master Plan. Hence, some of the historical data trends were not available, and hence a number of assumptions were made to plot the historical trends. Therefore, a number of estimates are indicative, but have been corroborated to the extent that it would not impact the trends indicated in the plans. However, a ground survey would be advised before the project implementation starts, which in any case would be the requirement.
g. Further, it is proposed that a dedicated Project Management Unit (PMU) be set up in Rajapalayam which is under the Tamil Nadu Green Climate Company. The role of the PMU would primarily be to work with the various Government Departments to ensure timely implementation of the proposed recommendations, including overseeing the development of DPRs, tender documents etc. Further the PMU would also help in developing information, education and communication strategy and implementation with the view to ensure that people are made aware of climate change and the solutions to address climate change and to imbibe the principles of Lifestyle Changes for Environment.
h. It is proposed that the PMU will have a staff of four people, led by a Projector Director, one Deputy Director, one Outreach Coordinator and one Research Staff. Further, the Tamil Nadu Green Climate Fellows for the district would also be part of the PMU

To conclude, the plans that are proposed and the pathways for decarbonisation are robust and based on feasibility analysis and consultations with a wide range of stakeholders. As already indicated, Rajapalayam is endowed with a combination of very enthusiastic citizens and natural factors that enhance the potential of the town to be not only carbon neutral and net zero by 2041 but could also be carbon negative too.

Finally, the plans ensure that while the town transits to a carbon neutral town, it would in no way impact either livelihoods or income of people negatively, but in fact help in enhancing the wellbeing of all residents of Rajapalayam town.

Annexure -1

TNGCC
Tamil Nadu Green Climate Company

A Member of Ramco Group

Ground-Mounted Solar PV Potential Assessment for Rajapalayam LPA

Inside..

- Executive Summary
- Introduction
- About Ground Mounted Solar PV
- Energy Estimation
- Final Remarks

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Disclaimer

This report is based on the best available information in the public domain. Every attempt has been made to ensure the correctness of the data. However, we do not guarantee the accuracy of the data or accept responsibility for the consequences of the use of such data.

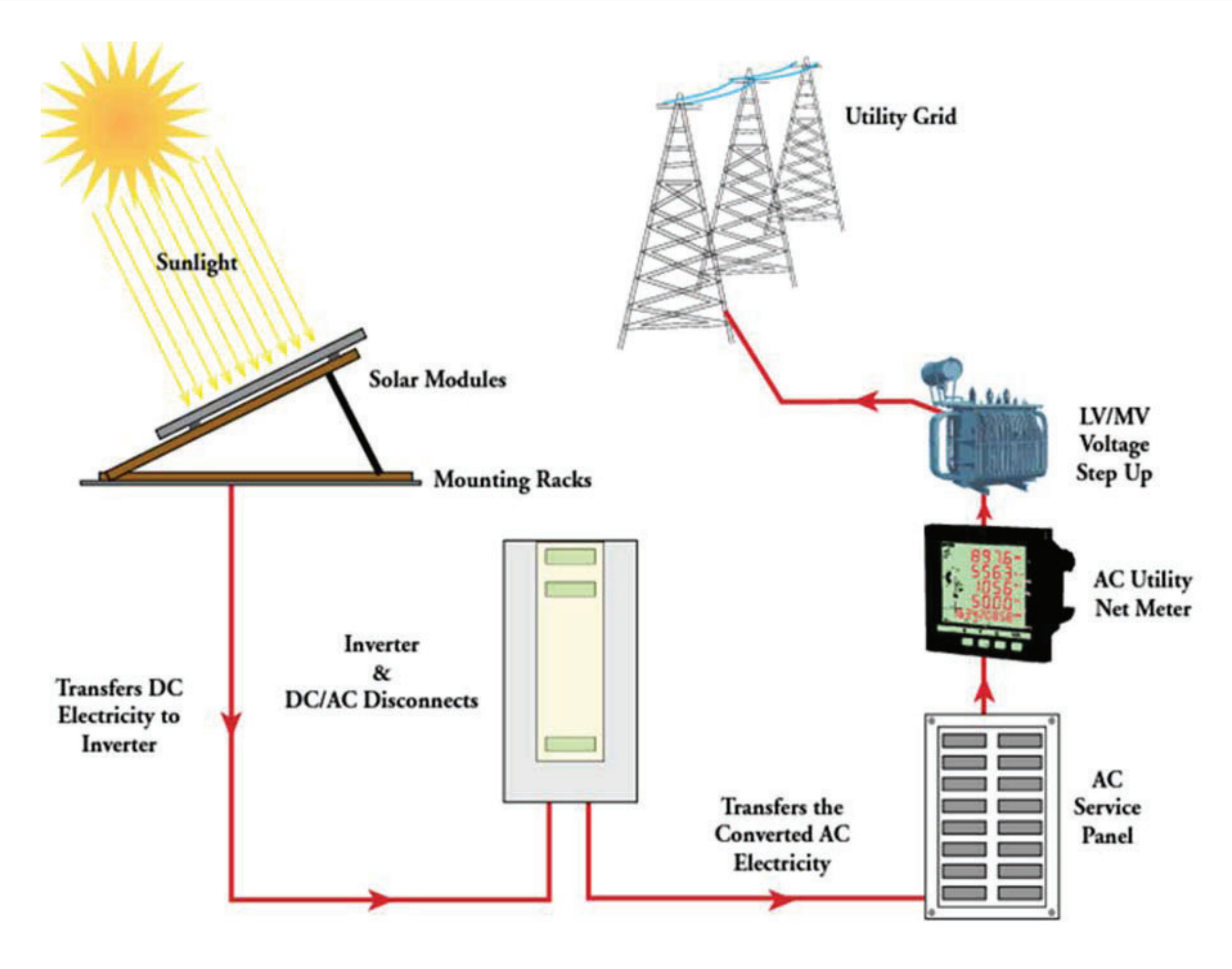
1. Introduction

India is situated in a higher solar insolation zone, receiving an average of 300 sunny days per year and abundant sunshine almost throughout the year. Based on the assumption that 3 percent of the wasteland area will be covered by solar PV modules, the National Institute of Solar Energy estimates that the nation has a solar potential of about 748 GW. Harnessing solar energy to its maximum potential is essential for reducing national emissions. The Indian solar industry has experienced rapid growth, with India having already deployed a solar PV capacity of 72 gigawatts (GW) to date. Among the various regions in India, Tamil Nadu, located in the southeastern part of the country, is at the forefront of solar PV adoption. The state has successfully deployed approximately 7,301[1] megawatts (MW) of solar PV capacity, and there are an additional 268 MW of projects in the development pipeline.

The purpose of this brief report is to assess the potential for ground-mounted solar photovoltaic (GPV) installations in the Rajapalayam Local Planning Area (LPA). This evaluation takes into account the evolving landscape of future development and changing land usage patterns to pinpoint idle land parcels suitable for the deployment of ground-mounted solar PV systems.

2. About Ground Mounted Solar PV

Solar energy is a clean, renewable resource that emits no emissions and contains a vast amount of potential energy that may be used in many different ways. A ground-mounted solar PV system (GPV) is one of the ways to generate electricity. This system uses the land parcels optimally, leading to a high volume of power generation. The main components of GPV system are solar modules, mounting structures, inverters, transformers, etc. In India, there are around 58 GW of GPV plants functional at the moment[2].



The main criteria for the selection of the sites of GPV projects are the availability of adequate land, easy access to the sites, availability of grid infrastructure, etc.

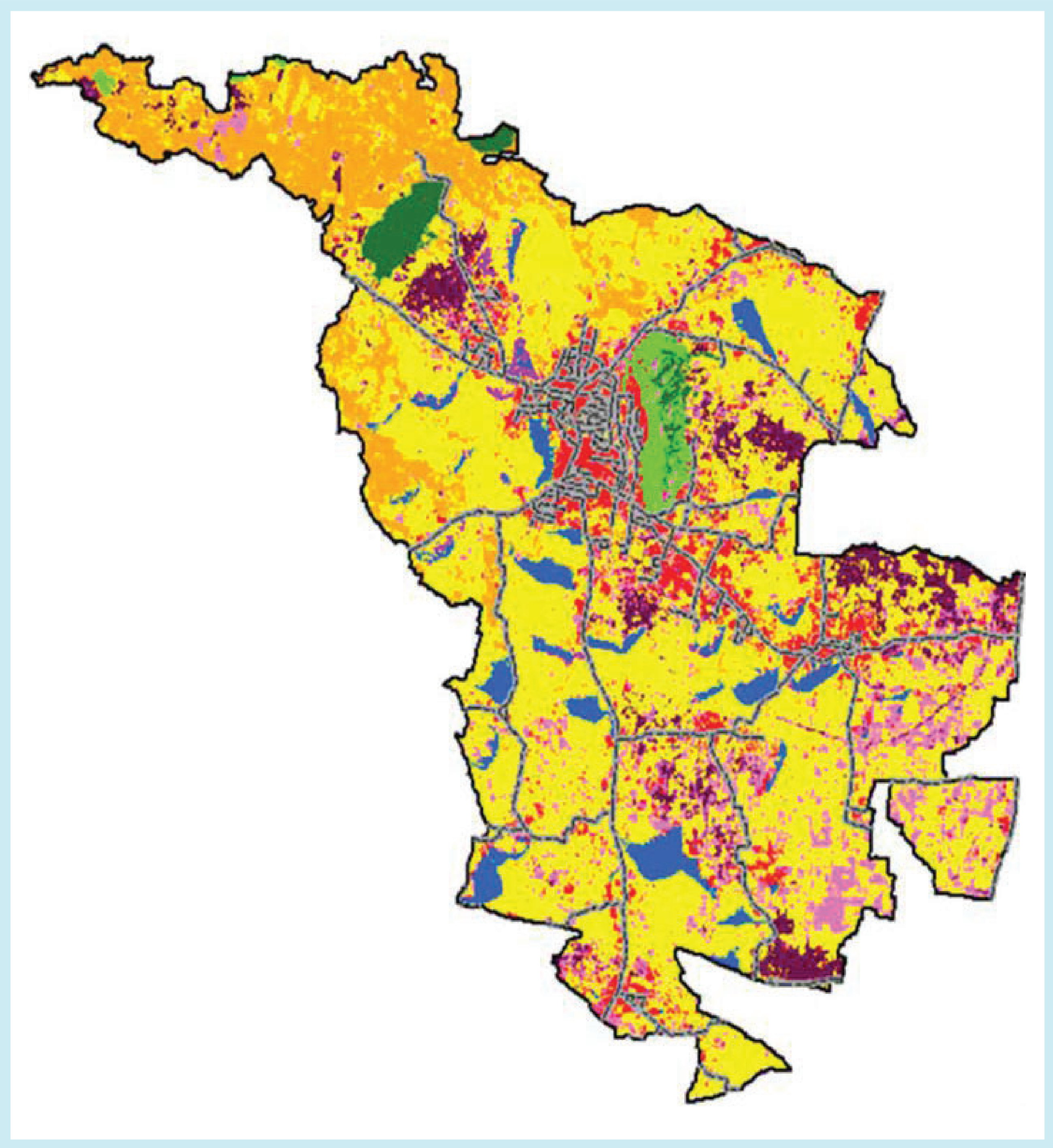


Figure 1: Current land use-landcover map 2023

In LPA, there is a huge availability of the fallow land, which can be used for multiple purposes. The current scenario of land use in Rajapalayam is shown in Figure 1. According to the master plan, the existing fallow land parcels are designated for various upcoming developments, including residential, commercial, industrial structures, and areas for aquifer recharge, among others as seen in Figure 2.

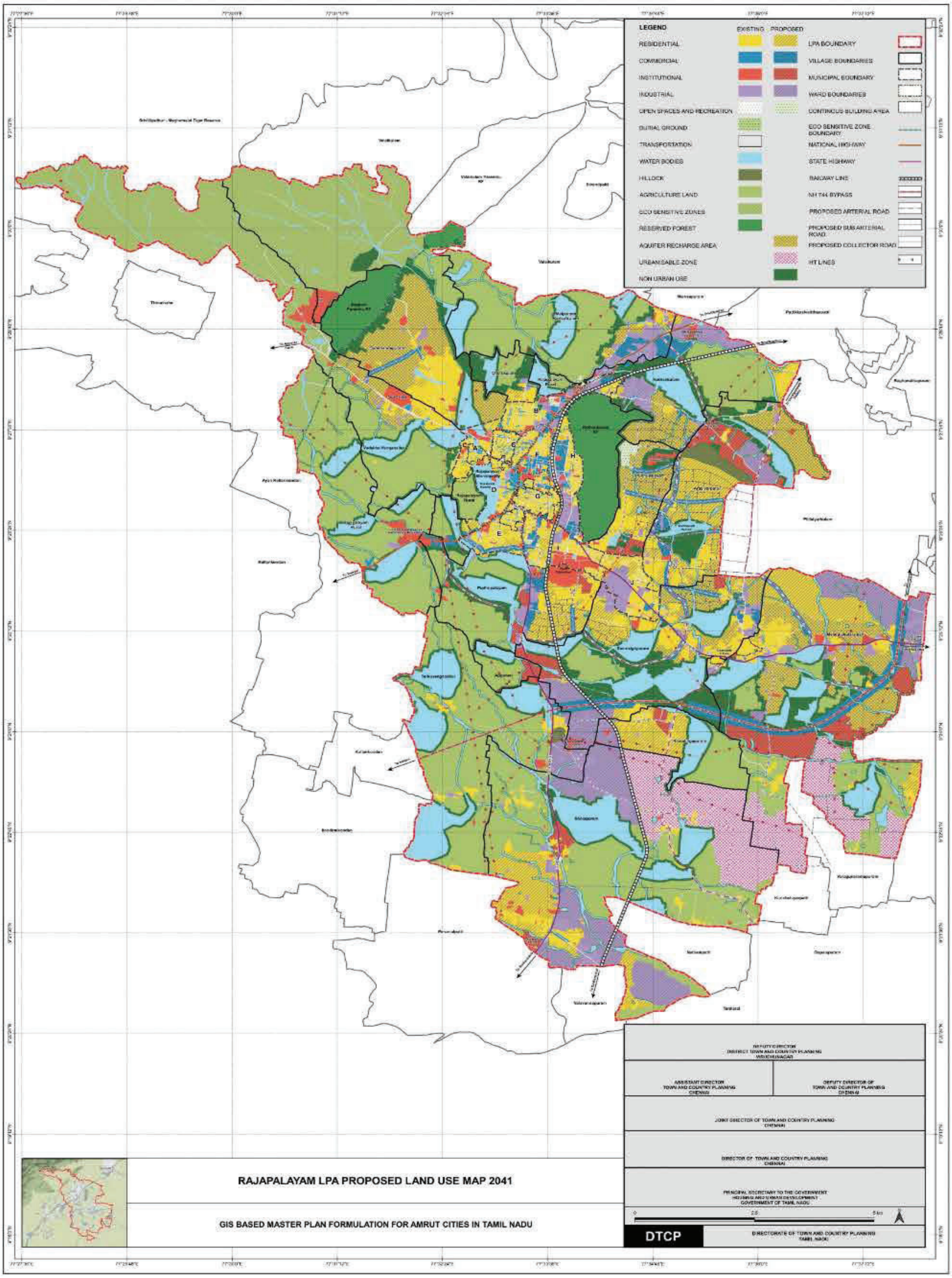


Figure 2: Proposed land use-landcover map 2041

In our assessment, we have identified a total of 24 sites, covering a combined area of 1472.98 acres. These sites have been identified through collaborative discussions with Tapasaya Design Studio. These fallow land parcels have a cumulative GPV potential of around 368 MW. The list of all sites with their individual potential is provided below in Table 1. Moreover, each site has also been mapped using GIS tool as can be seen in Figure 3.

Table 1: List of proposed sites for ground-mounted solar PV

S No.	Site area (Acres)	Latitude	Longitude	Nearest Substation	Distance (km)	Potential (in MW)
1	6.29	9.47885	77.5246	Mudangiyar	0.9	1.57
2	7.85	9.46456	77.5759	Thottiyapatti	1.6	1.96
3	5.02	9.43351	77.5635	Rajapalayam	0.89	1.26
4	7.85	9.43337	77.5663	Rajapalayam	0.58	1.96
5	11	9.41563	77.609	Rajapalayam	4.4	2.75
6	6.76	9.3659	77.5968	Nallamanaikampatti	4.9	1.69
7	4.58	9.36536	77.5957	Nallamanaikampatti	4.9	1.15
8	6.11	9.36507	77.5889	Nallamanaikampatti	4.4	1.53
9	7.01	9.36209	77.597	Nallamanaikampatti	5.3	1.75
10	6.98	9.36162	77.5921	Nallamanaikampatti	5.3	1.75
11	5.23	9.3627	77.5996	Nallamanaikampatti	5.4	1.31
12	5.48	9.45581	77.5768	Thottiyapatti	1.6	1.37
13	4.89	9.45139	77.5807	Thottiyapatti	1.5	1.22
14	9.57	9.42555	77.6306	Thottiyapatti	6.5	2.39
15	18.29	9.43045	77.6044	Rajapalayam	3.64	4.57
16	15	9.41972	77.5653	Rajapalayam	1.4	3.75
17	36.66	9.37061	77.5894	Nallamanaikampatti	4.6	9.17
18	27.71	9.36459	77.5941	Nallamanaikampatti	4.9	6.93
19	8.04	9.36509	77.5995	Nallamanaikampatti	5.2	2.01
20	87.06	9.36446	77.5921	Nallamanaikampatti	4.7	21.77
21	855.1	9.378997	77.595257	Nallamanaikampatti	1.3	213.78
22	46.6	9.396413	77.613339	Nallamanaikampatti	5.1	11.65
23	223.2	9.385711	77.61373	Nallamanaikampatti	4.92	55.80
24	60.7	9.377737	77.625662	Nallamanaikampatti	6.8	15.18

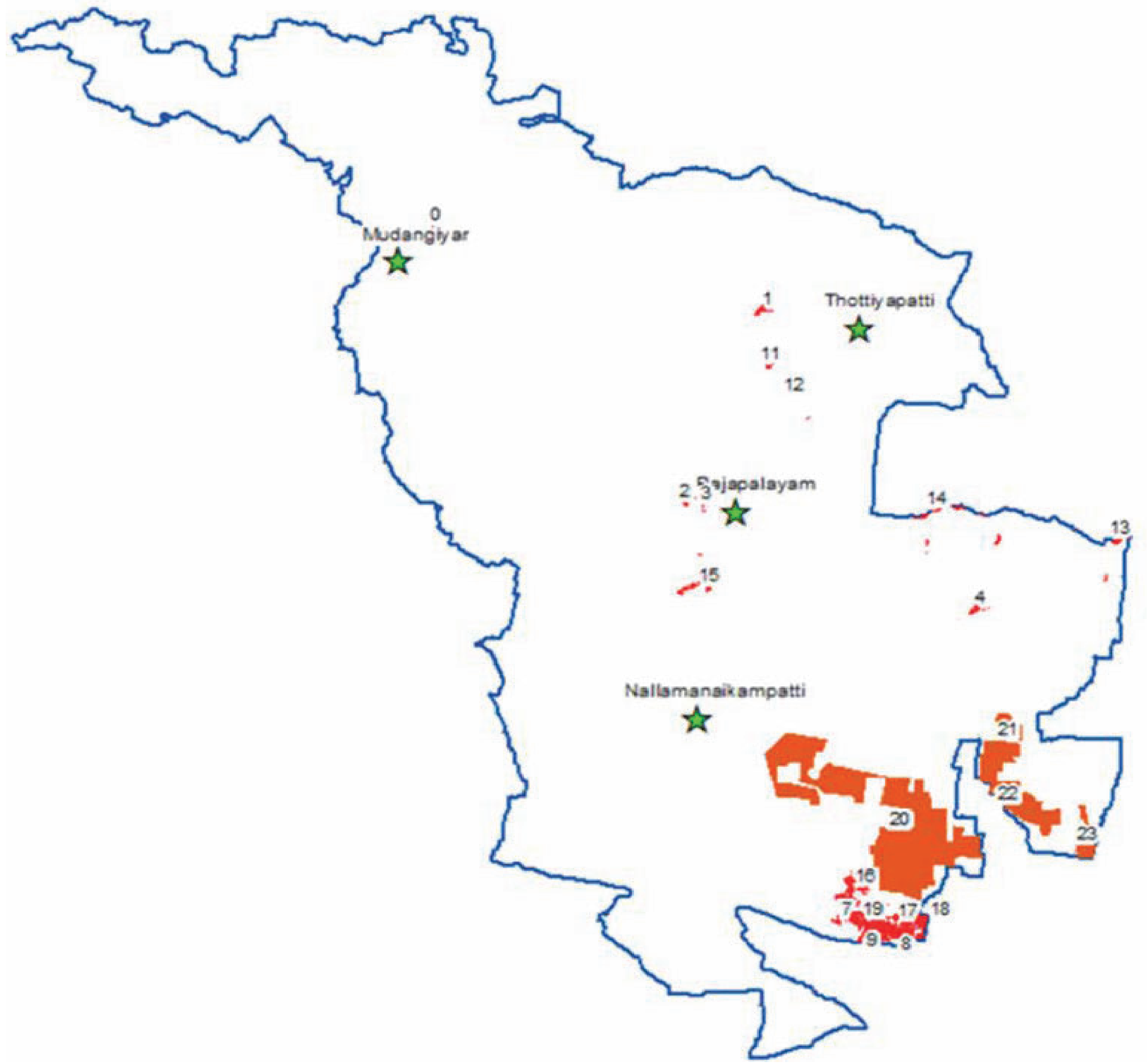


Figure 3: Potential sites for solar PV installation

3. Energy Estimation

To calculate the energy output from proposed GPV systems in the Rajapalayam LPA, we conducted a comprehensive analysis using PVSyst software. This analysis factored in local considerations such as shading and tilt, along with associated losses like soiling and module mismatch losses. The analysis has been done for a sample of 1 MW plant as shown in Figure 4 which also highlights the generation profile of the plant. This data comprises two significant values: P50 and P90. P50 signifies the energy generation level with a 50 percent likelihood of realization, while P90 represents the energy generation level with a higher 90 percent likelihood of realization. Typically, P90 values are deemed more reliable. Nonetheless, it's worth noting that in some instances, GPV systems have achieved energy outputs consistent with P50 projections. Based on the GPV potential assessment for Rajapalayam, the energy generation is estimated to be around 559 GWh according to P50 projections.

We additionally conducted an assessment for the same plant configuration but with multiple tilt angles. This was done to explore the potential for increased energy generation from GPV systems during specific months of the year. In these months, the energy generation exceeds what is achieved by the optimum tilt-based GPV system. Such adaptable systems are particularly well-suited to provide the administration with flexibility in meeting heightened energy demands from renewable sources during periods of increased consumption (For example: Summers). These variations can prove instrumental for the administration in formulating strategies aimed at achieving carbon neutrality of the district. The three tilt angles considered in the analysis are 0 degrees, 10 degrees, and 15 degrees. The annual generation for all the tilt angles is provided in Figure 5.

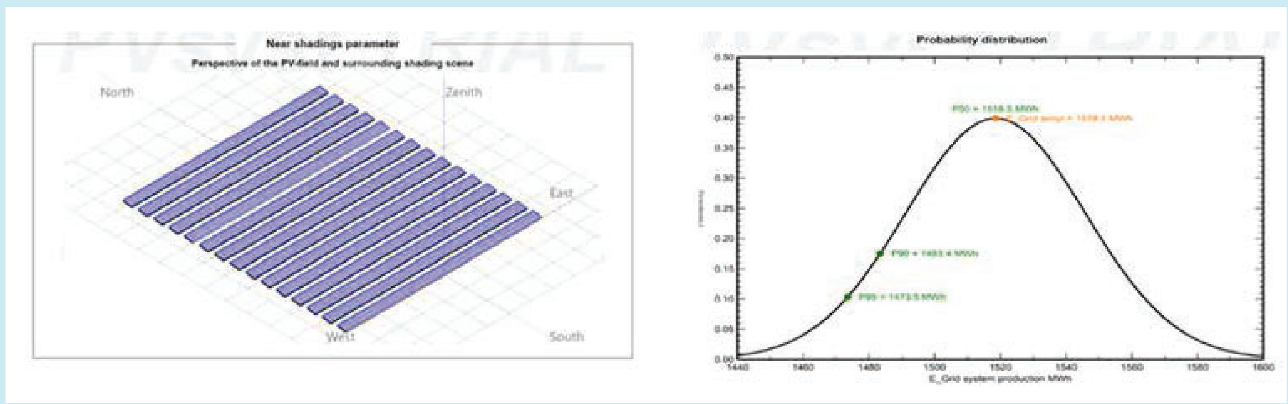


Figure 4: Ground-mounted system simulation and energy yield assessment

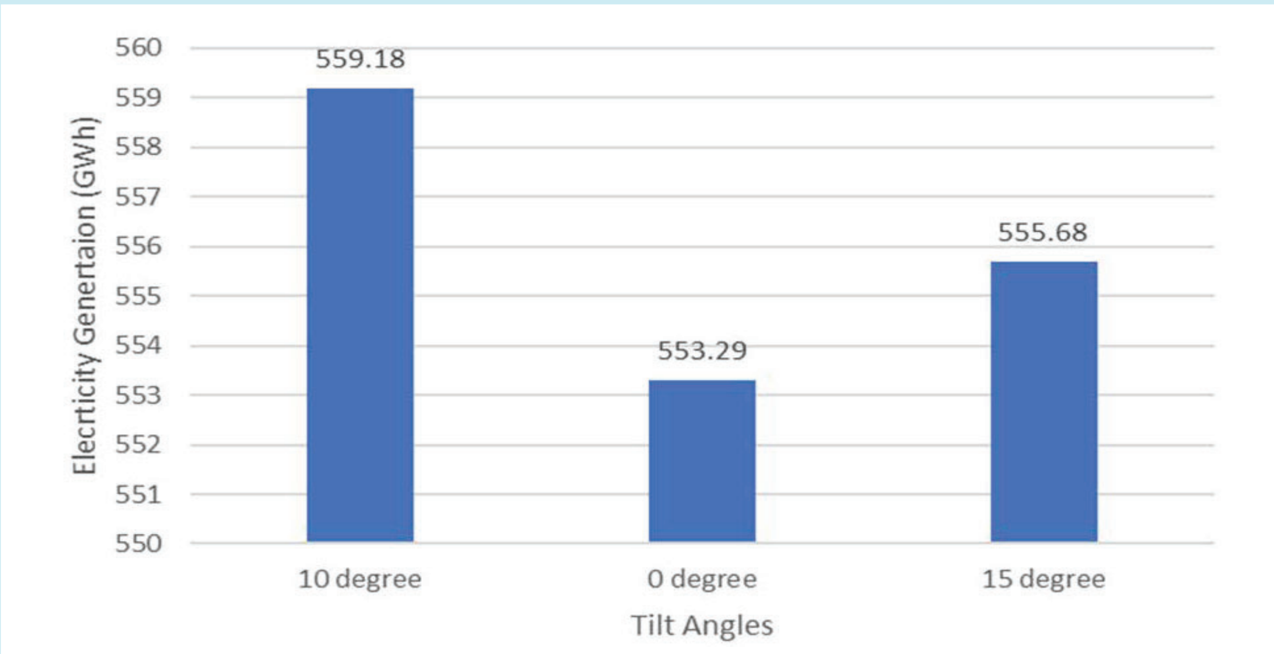


Figure 5: Annual electricity generation for different tilt angles

The month-on-month generation profile is interesting for all the tilt angles mentioned in Figure 6. The 0-degree configuration provides the maximum energy generation in summer months between March to July, whereas 15 degrees provides the maximum energy generation in winter months from December to January. These configurations are helpful in generating electricity as per the consumption profile of LPA. The 10-degree configuration is the optimum one and provides the maximum generation on an annual basis.

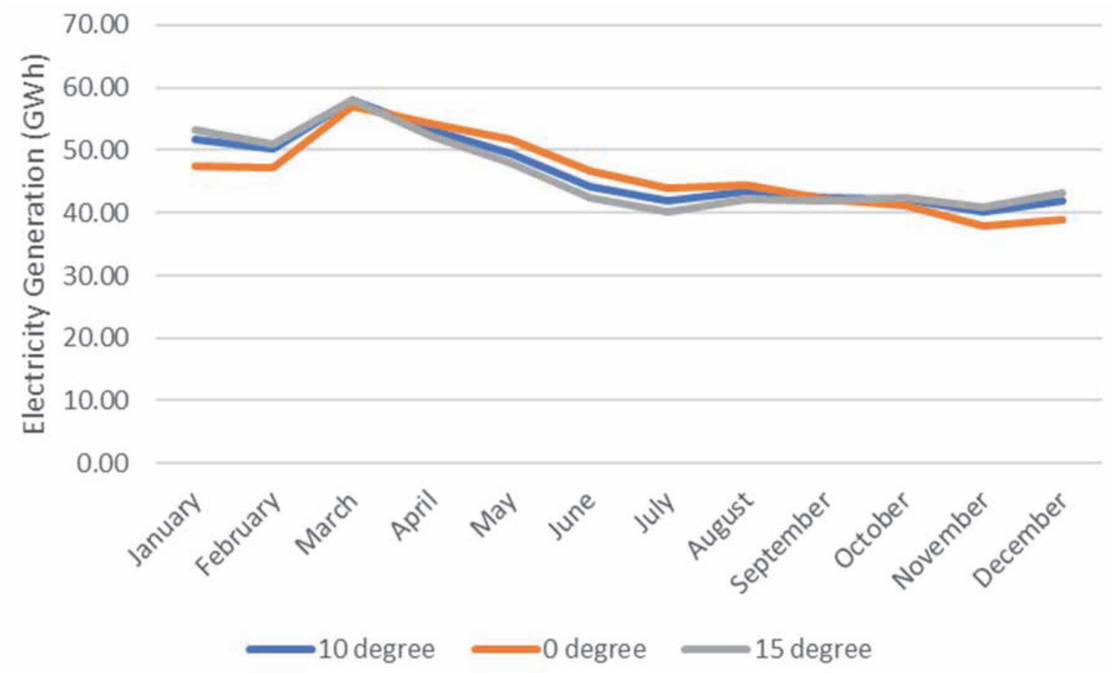


Figure 6: Monthly electricity generation for different tilt angles

4. Final Remarks

Based on our assessment, it is evident that there is substantial potential for GPV systems within the Rajapalayam LPA, even when accounting for the allocation of fallow land parcels for various future activities as outlined in the LPA's master plan. The potential is around 368 MW. Also, the assessment for different tilt angles shows that maximum generation can be obtained using the 10-degree tilt, while 0-degree and 15-degree tilt angles show good results in the summer and winter seasons respectively. The maximum energy generation potential is around 559 GWh for 10 degrees.

The GPV system can partially fulfill the energy consumption requirement of LPA, helping in the decarbonization process of the area. In the current scenario, as greener energy is becoming the need of the hour, solar energy plays an important role. Not just from the environmental benefit perspective but also it is much more economical than conventional electricity.

Endnotes

[1] https://iced.niti.gov.in/energy/electricity/generation
[2] https://iced.niti.gov.in/

Annexure -2

TNGCC
Tamil Nadu Green Climate Company

A Member of Ramco Group

UNVEILING THE ROOFTOP SOLAR PV POTENTIAL IN RAJAPALAYAM LPA

A STUDY REPORT

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Executive Summary

The Rajapalayam Local Planning Area (LPA) possesses a substantial Rooftop Solar Photovoltaic (RTPV) potential, ranging from **332.47 MW to 387.88 MW,** with the capacity to generate **458 GWh to 534.43 GWh** of annual electricity based on varying shadow free area on the roofs (60 percent, 70 percent). This offers a remarkable opportunity to offset the region's annual consumption of around 550 GWh. However, realizing this potential requires strategic efforts, including consumer awareness campaigns, educational materials, and a tailored demand aggregation framework. Embracing RTPV systems can usher Rajapalayam LPA into a greener, more sustainable energy future, benefiting both the community and the environment.

Shadow Free Area on Roofs	RTPV Potential (MW)	Total Annual Energy Generation Potential (GWh)
60%	332.47	458
70%	387.88	534.43

1 Introduction

With an annual average of 300 sunny days, India lies in the higher solar insolation region that is endowed with abundant sunshine almost throughout the year. According to the National Institute of Solar Energy, the country has a solar potential of roughly 748 GW, assuming that 3 percent of India's wasteland would be covered with solar PV modules. Since the potential is so huge the maximum utilisation of solar energy will lead to reducing the country's emissions. As per the recently revised Nationally Determined Contributions (NDCs), the government has approved a target for non-fossil fuels to account for around 50 percent of total power generation capacity by 2030.

In India, there has been a significant increase in the solar power capacity as observed in Figure 1. To date, around 71.6 GW of solar capacity has been deployed in India and of this around 9 GW is rooftop solar. The solar capacity has increased at a CAGR of 34 percent from 2015-16[1] and the solar capacity is around 17 percent of the total installed power capacity in the country[2].

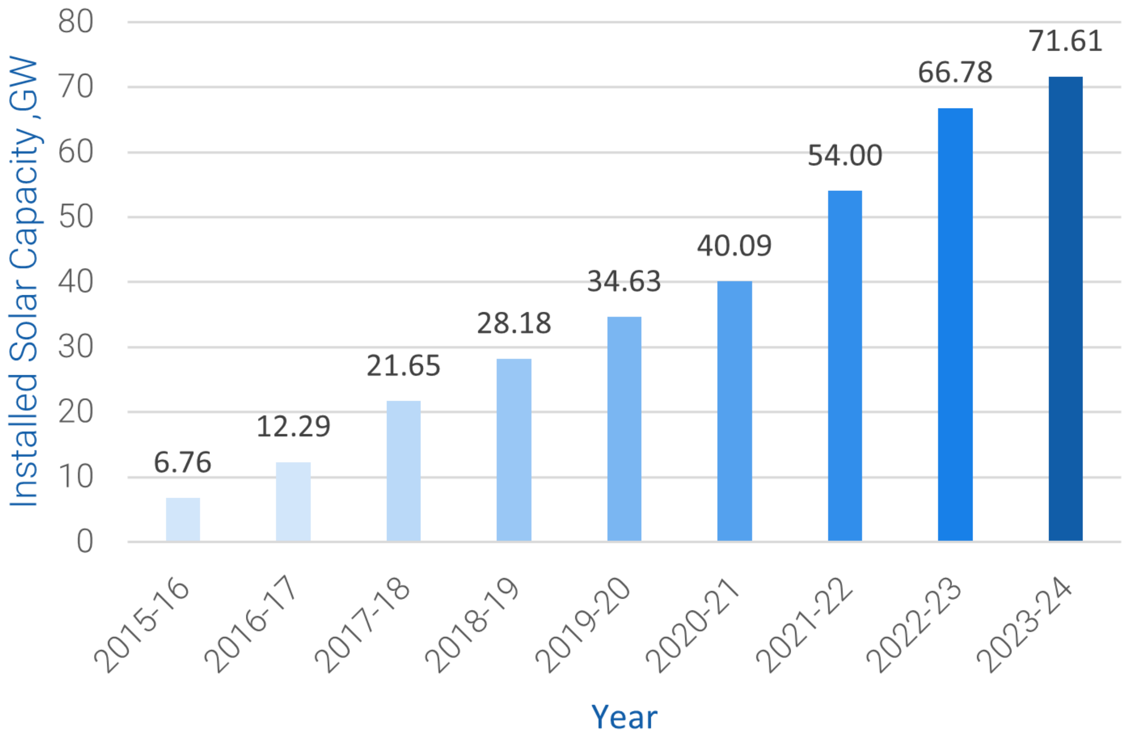


Figure 1: Year-on-year solar capacity addition

The objective of this report is to assess the Rooftop Solar Photovoltaic (RTPV) potential within the Rajapalayam Local Planning Authority (LPA). The analysis relies on data sourced from the LPA's master plan. Additionally, a comprehensive analysis using PVSyst has been conducted to determine the ultimate potential in terms of power capacity and energy generation.

[1]https://iced.niti.gov.in/analytics

[2]https://npp.gov.in/dashBoard/cp-map-dashboard

2 About Rooftop Solar PV (RTPV)

Various solar PV power plant configurations can be chosen to suit geographical requirements and availability. The primary topologies include Ground-mounted Systems, Rooftop Solar Systems (RTPV), and Floating Solar Systems. RTPV systems, in particular, have garnered substantial popularity in the Indian context due to their numerous advantages, and broadly fall under two-categories as shown in Figure 2. These systems consist of photovoltaic panels installed on the roofs of buildings or structures. This report provides a more comprehensive examination of grid-connected RTPV systems which are modular in design and enable individual consumers to transition into prosumers, tailoring the system to their needs. Furthermore, RTPV systems directly generate electricity at the point of consumption, which results in reduced Transmission & Distribution losses.

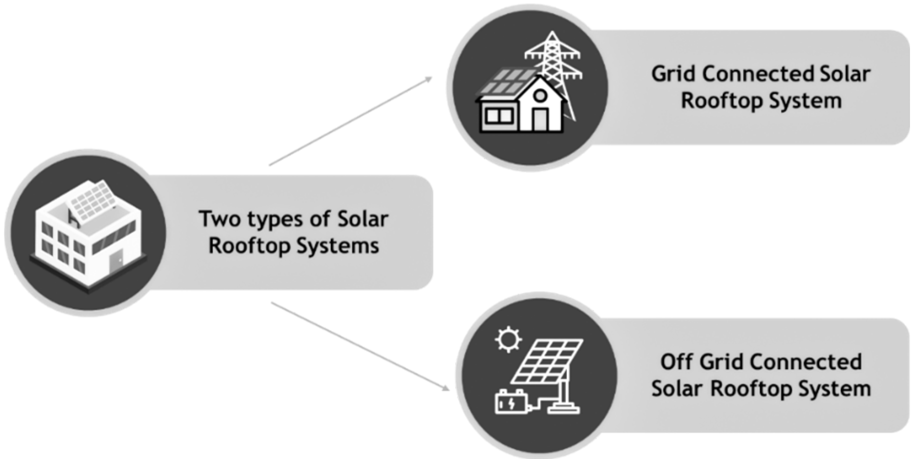


Figure 2: Type of RTPV systems

RTPV systems can be categorized according to the metering arrangement selected for a specific system. This arrangement serves as the interface between consumers and Discom, with three distinct types of metering arrangements:

- **Net-metering-** All solar PV systems generate power only during the daytime when the sun is available. In a net-metered system, the generated power is utilized for self-consumption, and excess power is exported to the grid as long as the grid is available. In cases, where solar power is not sufficient due to cloud cover or any other such reason, power is drawn from the grid to power the loads. A bi-directional meter or net-meter records the energy flow in both directions and at the end of the billing period, the net energy used is calculated. The beneficiary has to pay only for the net energy used.

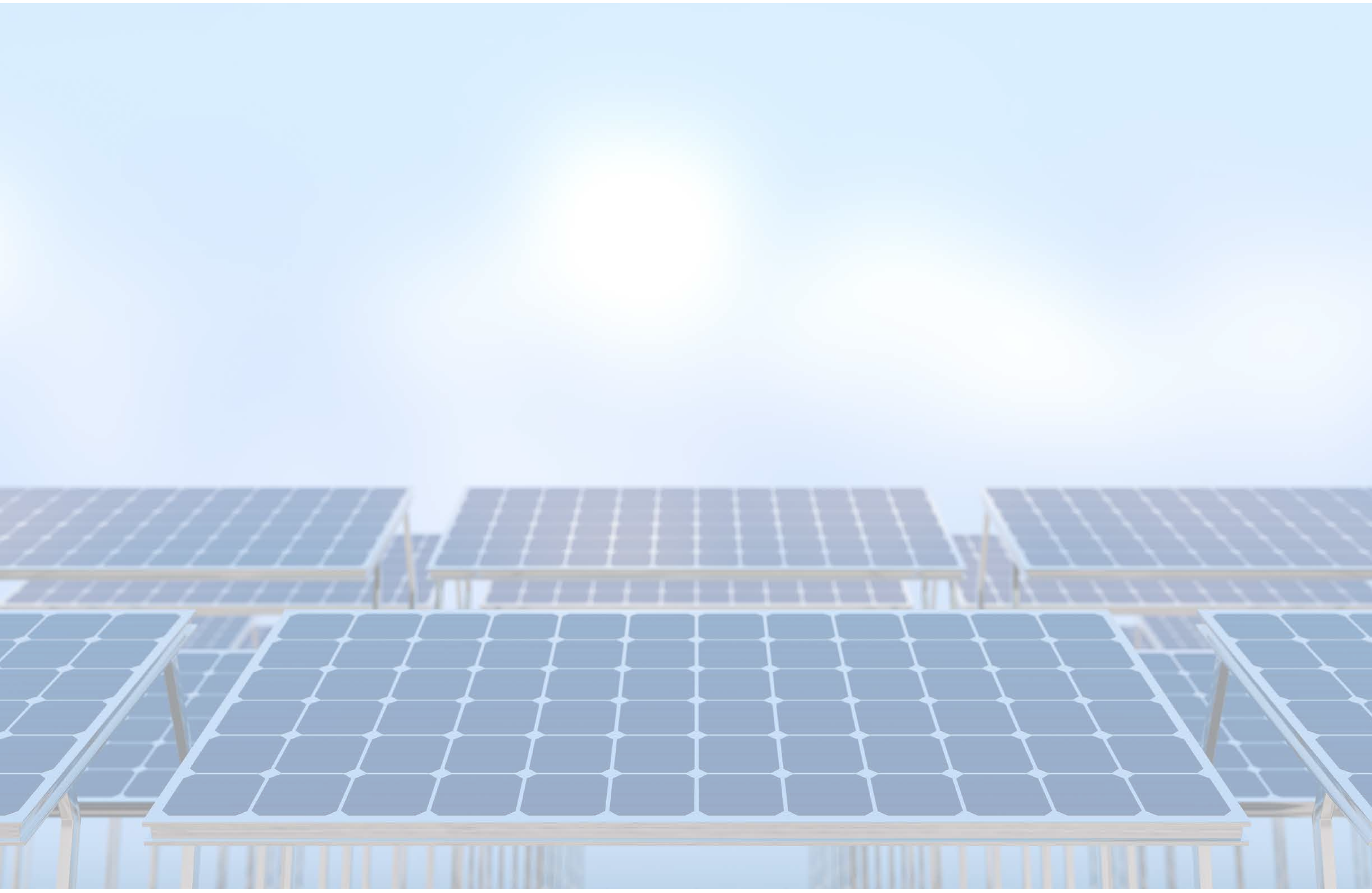
- **Net Billing-** Connections in net billing RTPV systems are similar to net metering. However, at the end of the billing cycle (normally a month), any excess energy in the grid shall not be carried forward like in net metering but shall be purchased by the DISCOM as per the pre-decided tariff. Therefore, energy banking in the grid is only within a billing cycle.

- **Gross Metering-** In gross metering, the power generated from the RTPV is only fed to the grid. The system owner gets paid by Discom for such exported power at a pre-decided tariff.

3 Solar Policy of Tamil Nadu viz-a-viz RTPV

In 2019, the State Government introduced a solar energy policy with an ambitious target of generating 9000 MW of solar power by 2023. The policy's primary objectives included ensuring solar energy is accessible, affordable, and available to all users. Here are some key policy highlights:

- Utility consumers have the flexibility to feed energy into the grid at any voltage level, with the stipulation of no wheeling service at the low tension (LT) level.
- Captive consumers can credit any surplus energy added to the grid at a rate determined periodically by the Commission.
- Buildings adhering to Energy Conservation Building Code (ECBC) regulations are mandated to incorporate solar PV and thermal energy systems.
- The policy promotes the use of electric vehicles and the establishment of solar-powered charging stations.
- Industrial establishments are encouraged to adopt Concentrated Solar Power Technology.
- For consumers, solar PV systems are permitted up to 100 percent of the sanctioned load.



4 Regulations for RTPV in Tamil Nadu

The Tamil Nadu Electricity Regulatory Commission introduced the 'Grid Interactive Solar PV Energy Generating Systems Regulations, 2021' to offer assistance and directives to Discoms in facilitating the implementation of RTPV systems in Tamil Nadu. The following are the key aspects of these regulations:

- Net metering facility available for all domestic consumers based on sanctioned load/ contracted demand.
- Domestic consumers can also choose a net feed-in facility.
- All consumer categories (except hut and agriculture) can opt for net feed-in up to their contracted demand or sanctioned load, or 999 kW, whichever is lower.
- Minimum size for the solar PV system for gross metering is 151 kW, up to a maximum capacity of 999 kW.
- New consumers or generators wanting to set up an RTPV system and sell all generated power are eligible for gross metering, up to 999 kW.
- Solar plant capacity must be represented by the output on the AC side.
- Interconnection with the licensee grid must adhere to specified technical standards and regulations.
- Cumulative capacity of solar PV systems under net metering or net billing connected to a distribution transformer should not exceed 90 percent of the transformer's capacity.
- The cumulative capacity of all solar generating systems under gross metering in high tension (HT) connections to a power transformer should not exceed 70 percent of the power transformer's capacity.

While the regulations comprehensively support RTPV deployment within the state, there remain a few provisions to consider for revision, such as:

- Under the net metering system, unused net units in a settlement period are lapsed. A provision could be implemented to compensate domestic consumers at a predetermined tariff for these unused units.
- In cases where eligible consumers fall under time-of-day (ToD) tariffs, electricity consumption during specific time slots, such as peak and off-peak hours, should be initially offset by the amount of electricity injected during the same time slot. Any surplus injection beyond consumption in a different time slot within a billing cycle should also be credited at a higher predetermined tariff, especially if it occurs during peak hours, which contributes to grid infrastructure stability.
- Network charges are imposed on the total energy generated in net metering, net billing, or net feed-in mechanisms, except for the gross metering mechanism. It must be considered to eliminate network charges across all regimes, following the example set by other states, as these charges have significantly discouraged the participation of the Commercial and Industrial segments in the RTPV space.

5 Economics of RTPV systems for Residential and Commercial Consumers in Tamil Nadu

The RTPV system has a direct impact on the monthly electricity bill of each consumer. With the subsidy provided by the Central Government to residential consumers, the effective cost of the system is reduced significantly. The details of monthly calculations and savings is provided in Table 1.

Table 1: Cost economics of an RTPV system in Tamil Nadu

Parameter	Unit	Values for Residential consumers	Values for C&I consumers
Capacity	kWp	2	20
Cost per kWp (Tentative)	₹	60,000	60,000
Cost of system	₹	1,20,000	1,20,0000
Total Subsidy	₹	29,176	0
Net Cost of the system	₹	90,824	12,00,000
Units' generation per month	kWh	270	2,700
Average unit cost	₹/kWh	6	7.5
Savings from Electricity per month	₹	1,620	22,950
Payback (Tentative)	Year	4.5	4.3
Life of Plant	Year	25	25

6 Profile of Rajapalayam LPA vis-à-vis Solar Rooftop Deployment

Solar Profile of Tamil Nadu

As of August 2023, the state's total power generation capacity stood at 37,985.75 MW. Notably, nearly half of this capacity, a substantial 49 percent is attributed to renewable energy sources, with an additional 6 percent derived from hydroelectric power. The remaining 42 percent is supplied by thermal power plants, while nuclear power contributes 4 percent to the state's electricity capacity mix. To provide a detailed breakdown, the installed capacity for renewable energy (RE) amounts to 18,497.21 MW, as illustrated in Table 2 below:

Table 2: Tamil Nadu's installed renewable power capacity (in MW) as of 31.08.2023

Small Hydro	Wind	Biomass	Solar					Total Capacity
			Ground Mounted	Rooftop	Hybrid	Off-grid	Total Solar	
123.05	10247.97	1043.7	6567.41	449.22	0	65.86	7082.49	18497.21

Source: Ministry of New and Renewable Energy, 2023

Tamil Nadu is endowed with significant renewable energy potential. The state is blessed with almost 300 sunny days in a year. The state ranks as the fourth largest in India in terms of solar power deployment. Notably, solar capacity in Tamil Nadu has experienced remarkable growth, increasing from 2575.22 MW in 2018-19 to 7082.49 MW in 2023-24 (as of Aug-23), reflecting a compound annual growth rate of 22 percent. Figure 3 illustrates the year-on-year solar capacity installation in the state.

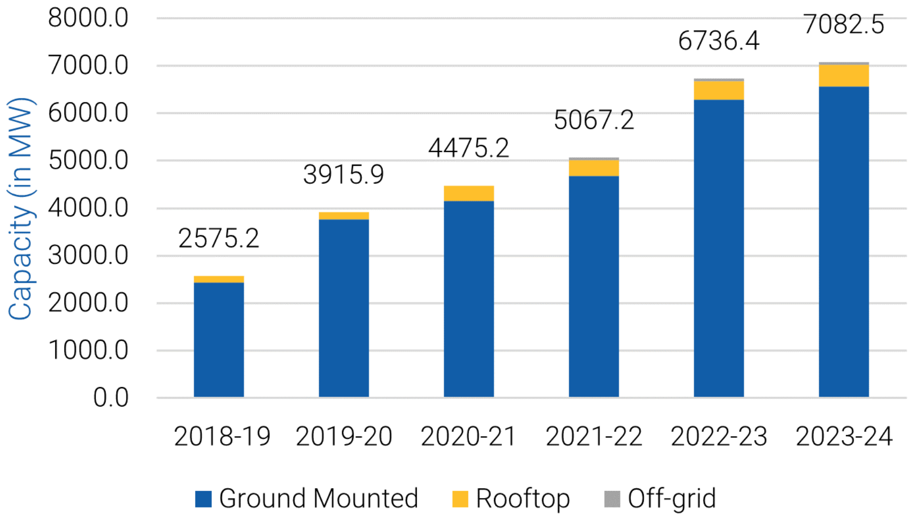


Figure 3: Year-on-year solar capacity installation in Tamil Nadu

The state government has undertaken several initiatives and schemes aimed at promoting solar energy adoption within the state. According to the latest report from the Central Electricity Authority (CEA) on renewable energy under-construction projects, there are currently 1647.6 MW of wind and 250 MW of solar projects in the construction phase in the state.

Electricity Consumption in Rajapalayam LPA

On average, the Rajapalayam LPA had an annual average electricity consumption of around 550 GWh over the last five years as shown in Figure 4. As of 2021, solar energy constituted 13.54 GWh[3] of the total annual supplied electricity.

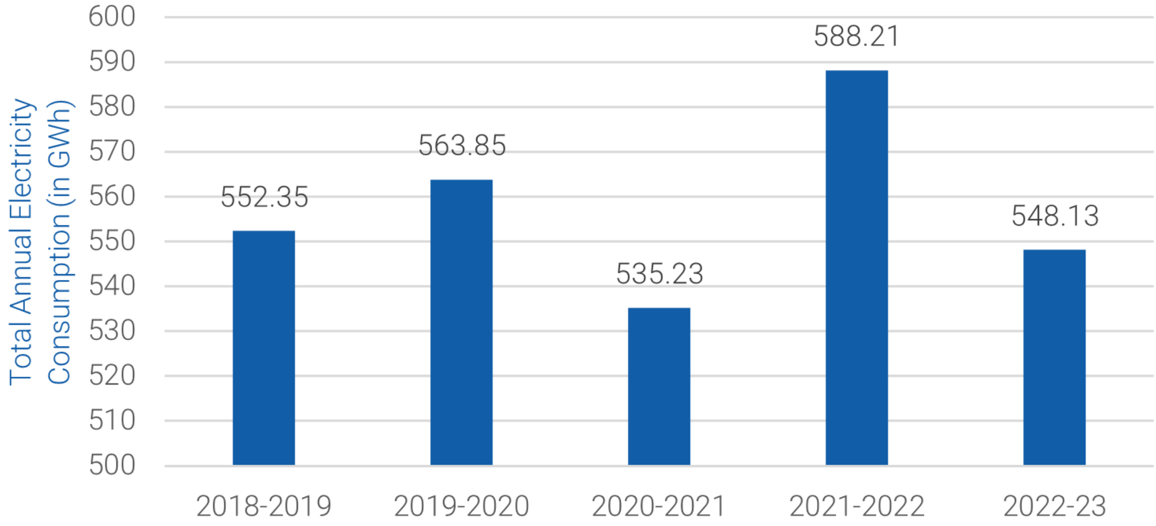


Figure 4: Annual electricity consumption in Rajapalayam LPA

Further, the break-up of electricity consumption as observed in Table 3, highlights the heavy industry segment as having the highest electricity consumption.

Table 3: Division of electricity consumption by consumer category in Rajapalayam LPA

Consumer Category	Electricity Consumption (in MWh)				
	2018-19	2019-20	2020-21	2021-22	2022-23
Domestic Load	87176.70	89304.77	91109.19	92838.01	95329.45
Commercial (V)	26244.42	26942.32	27121.27	27461.47	28330.05
Industry LT (IIIA, IIIB)	32509.79	32646.78	33622.91	35013.96	36527.74
Public Lighting (IIA) and Others (IIB, IB, IIC, VI)	9914.76	10249.67	10750.01	10832.68	11323.19
HT Industry	378529.58	387017.87	358185.17	403177.46	357534
Agriculture (IV)	17970.511	17693.314	14438.989	18887.062	19082.7
Total Consumption (GWh)	552.35	563.85	535.23	588.21	548.13

[3] https://www.aurovilleconsulting.com/rajapalayam-lpa-ghg-emissions-inventory-fy-2021-22/

Solar Presence in Rajapalayam LPA

Currently, the LPA possesses 28 solar pumps[4] that have been set up for irrigation. In the Nallamanaikkanpatti sub-station limits, a 50 MW solar project has been commissioned[3]. A household-level survey conducted within the municipal limits indicated that a majority of households were reliant on the grid-supplied electricity. Only 9 percent[3] of the households used alternate sources of power and solar power constituted a minor 6 percent[3] of this specific group of households. Further, there are norms in place for commercial buildings to adopt solar rooftop and solar water heaters. However, a gap in awareness initiatives and implementation strategies have resulted in a lacklustre uptake of solar energy.

[4] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://rajapalayamlpa.com/wp-content/uploads/2023/08/230719 Volume_1_lowres.pdf

7 Methodology

Description of the Study Area

According to the master plan formulated for Rajapalayam LPA, the combined area covered by buildings, which includes both built-up structures and compounds, amounts to approximately 2.08 crore square meters. Out of this, the built-up area specifically accounts for around 55 lakh square meters. Furthermore, the residential category dominates with a substantial 60 percent share of built-up area. The industrial category following closely behind at 25 percent as can be seen in Figure 5. This data underscores the importance of directing the efforts toward solar rooftop deployment, with a primary focus on these two significant segments.

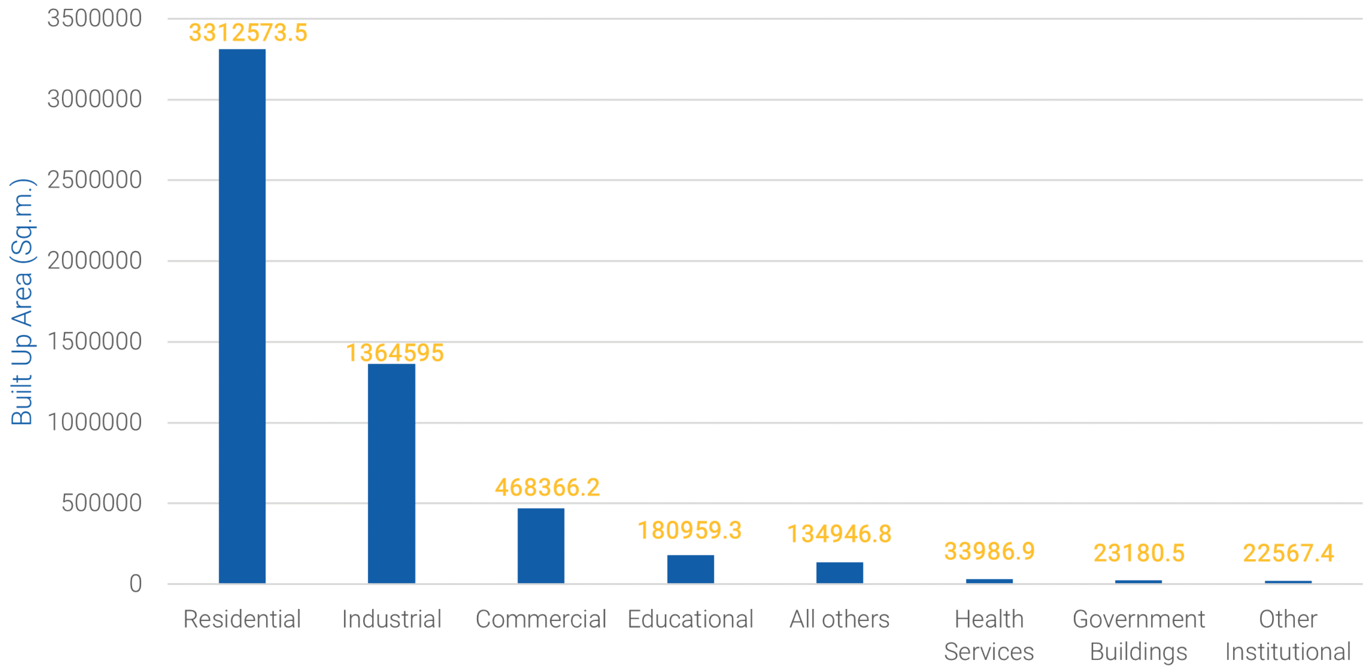


Figure 5: Segment-wise built-up area division

Mapping of Suitable Rooftop Area

By utilizing the data for built-up area, we conducted an analysis to determine the total RTPV potential for Rajapalayam LPA. This analysis took into account two critical factors: the typically shadow-free area available for RTPV deployment, which ranges from 60 to 70 percent of the total built-up area[5], and the thumb rule that every 10 square meters of shadow-free space can accommodate a 1 kW RTPV system[6].

Considering these factors, the estimated RTPV potential in Rajapalayam LPA falls within the range of **332.47 MW** with 60 percent of the built-up area as shadow-free space to **387.88 MW** based on 70 percent of the built-up area being shadow-free. The potential for each specific segment is illustrated in Figure 6.

[5]Vasudha Foundation Analysis

[6]https://solarrooftop.gov.in/pdf/faq_new.pdf

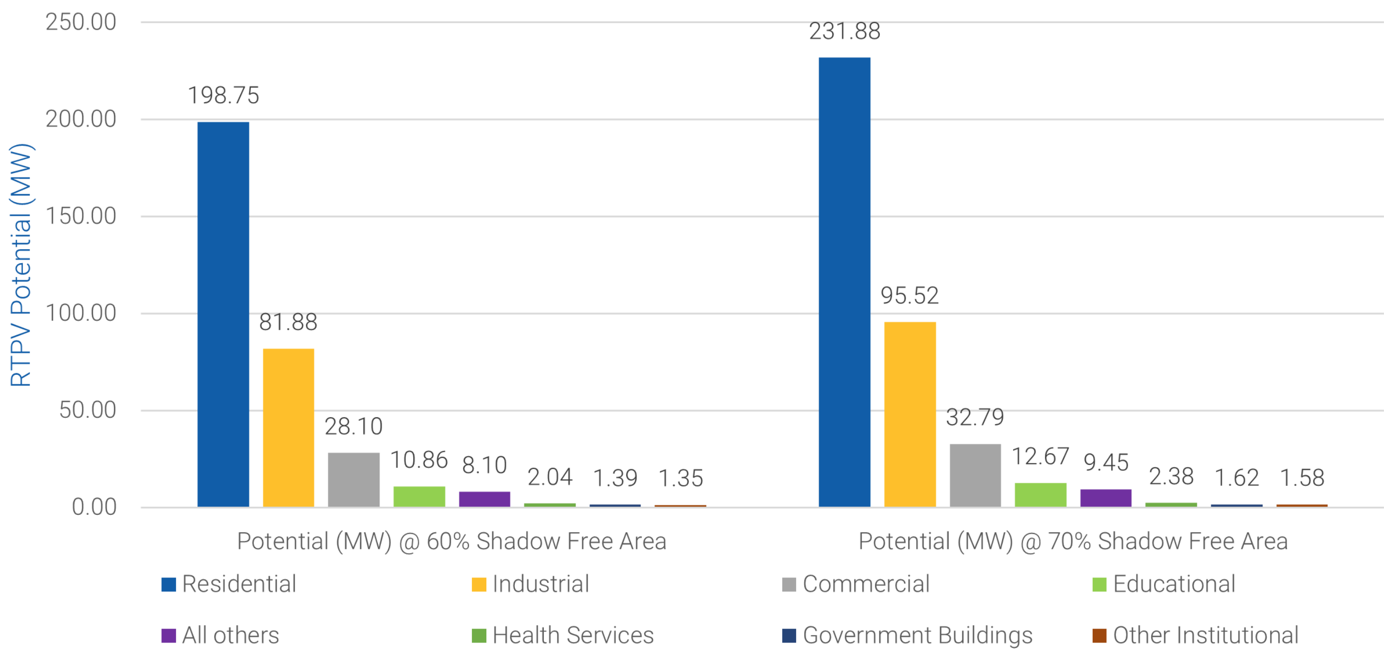


Figure 6: Sensitivity analysis of RTPV potential for all segments against varied shadow free area assumption

Energy Estimation Calculation for Sample Buildings

To calculate the energy output from RTPV systems in the Rajapalayam LPA, we conducted a comprehensive analysis using PVSyst software. This analysis factored in local considerations such as shading and tilt, along with associated losses like soiling and module mismatch losses. Detailed reports from PVSyst for a selection of residential and industrial buildings are available in Annexure I.

As showcased in Figure 7, the analysis of the chosen residential building suggests that a 6 kW RTPV system can be installed using 16 PV modules, each with a capacity of 380 Wp. The assessment also yielded potential energy generation data for this RTPV system, as illustrated in Figure 7. This data comprises two significant values: P50 and P90. P50 signifies the energy generation level with a 50 percent likelihood of realization, while P90 represents the energy generation level with a higher 90 percent likelihood of realization. Typically, P90 values are deemed more reliable. Nonetheless, it's worth noting that in some instances, RTPV systems have achieved energy outputs consistent with P50 projections.

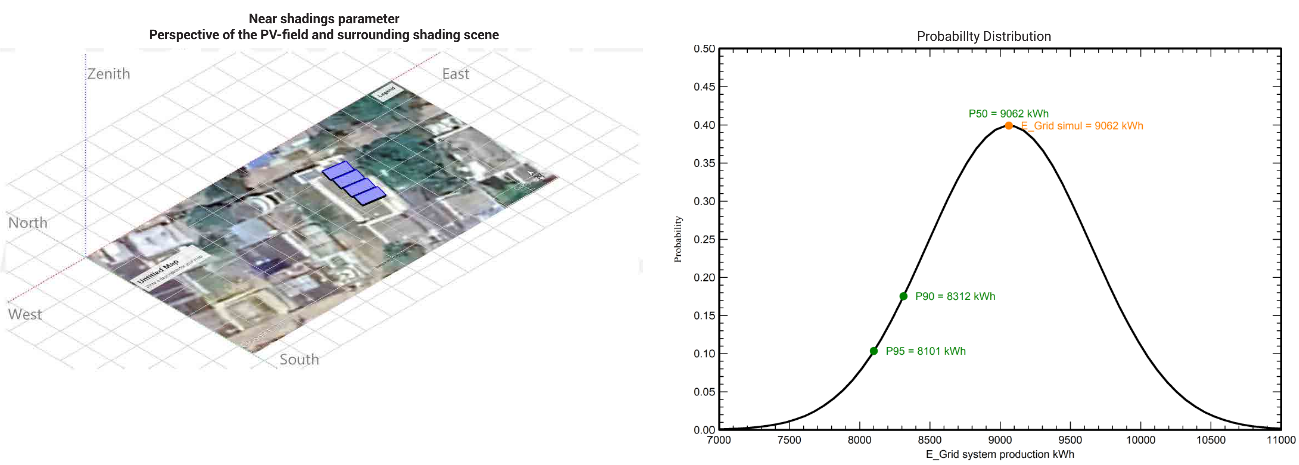
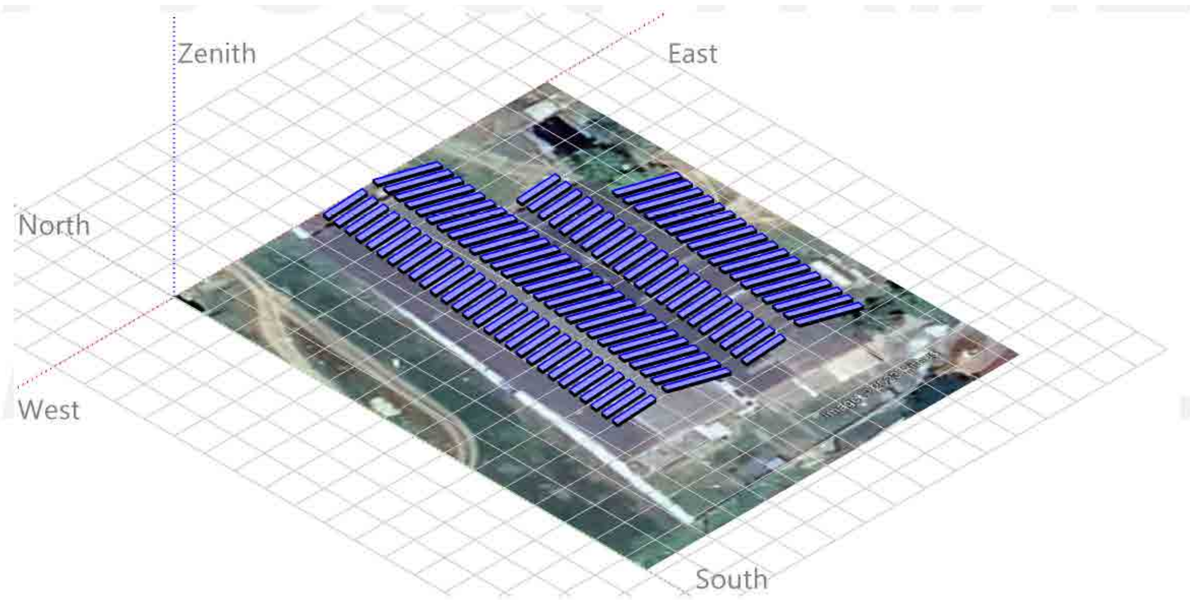


Figure 7: RTPV assessment on residential building in Rajapalayam LPA and estimated energy generation

A similar evaluation for an industrial shed building, including an assessment of energy potential, was carried out as depicted in Figure 8. For this particular building type, it was determined that an RTPV system with a capacity of approximately 146 kWp, consisting of 384 modules with 380 Wp each, is suitable for deployment. These practical on-site assessments along with the potential identified in the preceding section have been instrumental in determining the overall achievable energy generation for the Rajapalayam LPA.

Near shadings parameter
Perspective of the PV-field and surrounding shading scene



Probabillty Distribution

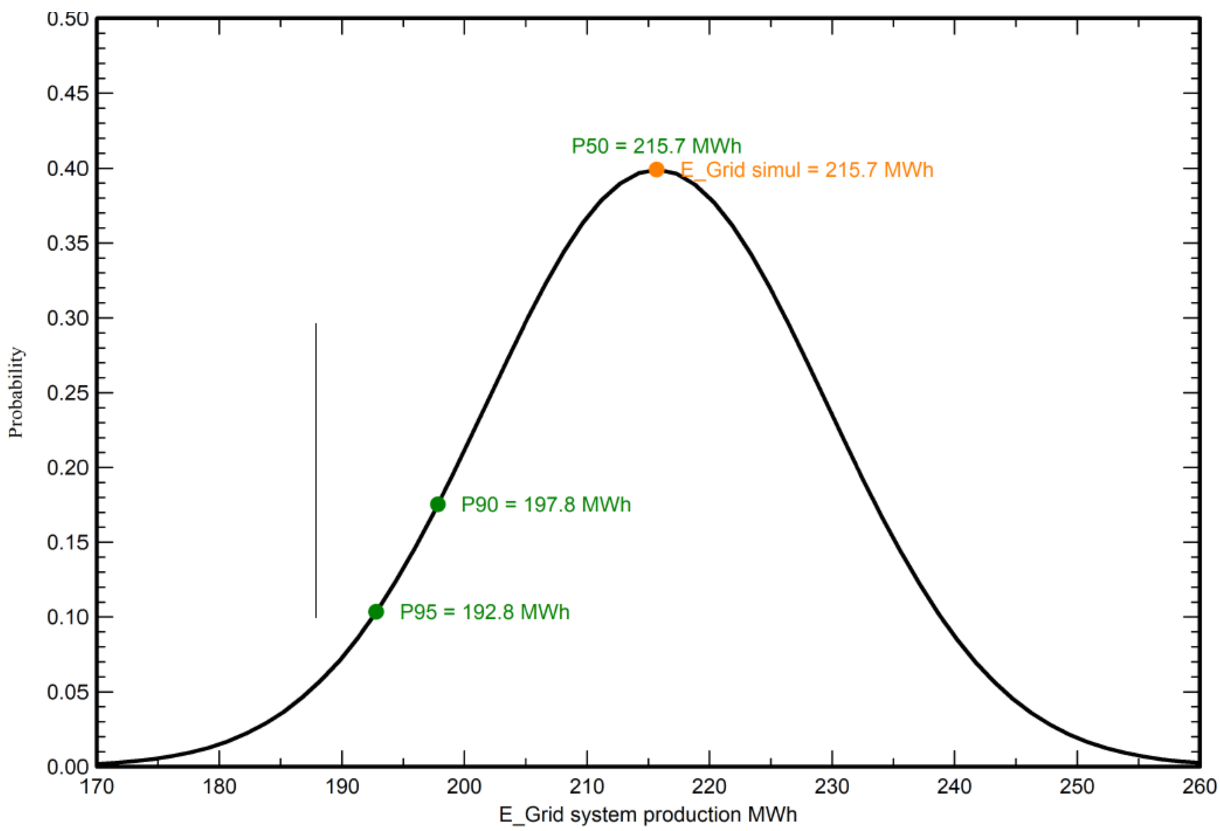


Figure 8: RTPV assessment on industrial building in Rajapalayam LPA and estimated energy generation

8 Total Energy Estimation against Identified RTPV Potential

As per the detailed analysis, the annual energy generation potential ranges from 458 GWh to 534.43 GWh, depending on the varying percentages of built-up area available as shadow-free for the P90 scenario, as depicted in Figure 9. The month-to-month variation in energy generation, illustrated in Figure 10 for the P50 scenario, is particularly interesting with February and March months leading to heightened energy generation. Another intriguing aspect is that this level of energy generation is at par with the existing electricity consumption in the Rajapalayam LPA, which typically hovers around 550 GWh. This underscores the significance of RTPV systems as a pivotal solution for decarbonizing electricity consumption in the LPA region.

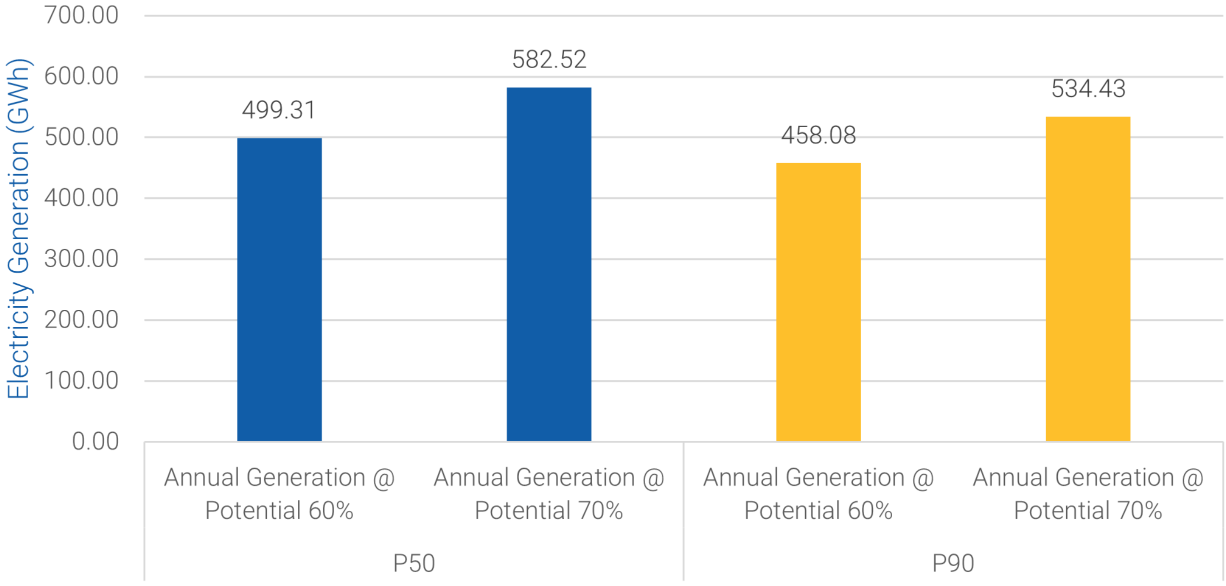


Figure 9: Total annual electricity generation under P50 and P90 buckets

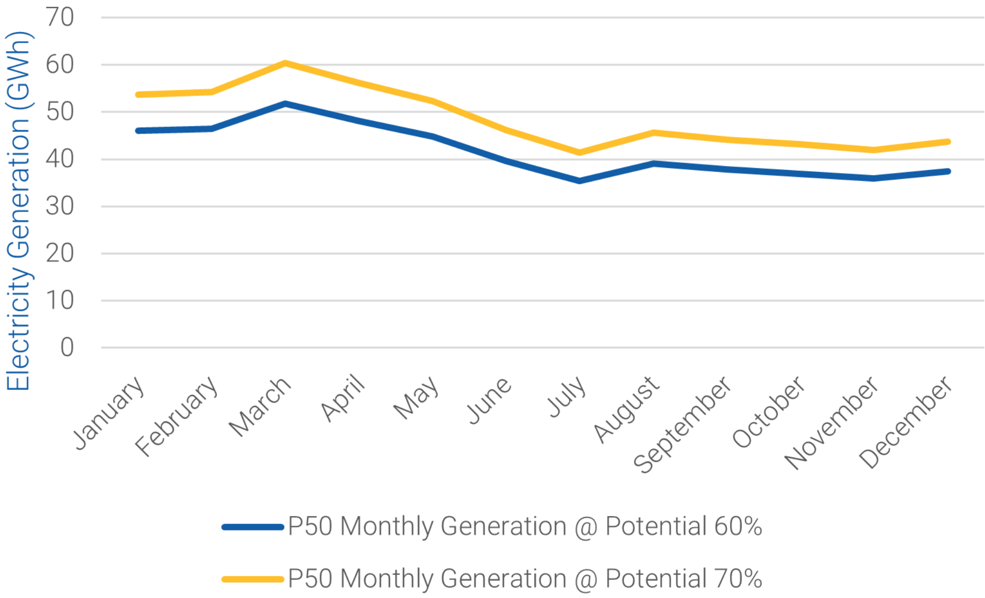


Figure 10: Monthly variation of electricity generation in Rajapalayam LPA for deployment against total identified RTPV potential

9 Final Remarks

Our assessment has revealed the significant RTPV potential within the Rajapalayam LPA. Notably, this potential falls within the range of **332.47 MW with 60 percent** of the built-up area as shadow-free space to **387.88 MW based on 70 percent** of the built-up area being shadow-free. Furthermore, the key highlights of this potential assessment underscore that the LPA has the capacity to generate an impressive annual electricity output, ranging from 458 GWh to 534.43 GWh. This range is contingent on the availability of shadow-free areas for RTPV systems. What adds to the appeal of this assessment is the proximity of this potential electricity generation to the region's existing annual consumption, which typically stands at around 550 GWh.

The significance of RTPV systems in decarbonizing electricity consumption in the LPA is undeniable. With the opportunity to offset a significant portion of the region's energy needs, RTPV systems offer a sustainable and environmentally responsible solution. However, realizing this potential hinge on a strategic approach.

To ratchet up RTPV system deployment, concerted efforts in consumer awareness campaigns are crucial. Educating consumers about the benefits of RTPV systems, the economic advantages, and the environmental impact can drive greater adoption. Additionally, the development of comprehensive brochures and frequently asked questions (FAQs) can play a pivotal role in providing consumers with the necessary information and guidance to make informed decisions. Furthermore, the establishment of a demand aggregation framework tailored to the C&I segment can streamline the implementation process, making it more accessible and cost-effective for businesses.

Requiring C&I consumers to install RTPV systems can lead to a substantial increase in solar deployment in Rajapalayam. Furthermore, considering that these consumers are subject to a higher tariff of approximately INR 6.8/kWh in FY 22-23, the option of net billing allowed in Tamil Nadu enables them to utilize the solar rooftop-generated energy to fulfill their in-house energy demands before exporting surplus electricity to the grid. This transition is economically advantageous for them. It's evident that C&I consumers represent the most readily accessible opportunity for the widespread adoption of RTPV systems, with a potential capacity ranging from approximately 109.98 MW at 60% shadow-free area coverage to 128.31 MW at 70% shadow-free area coverage.

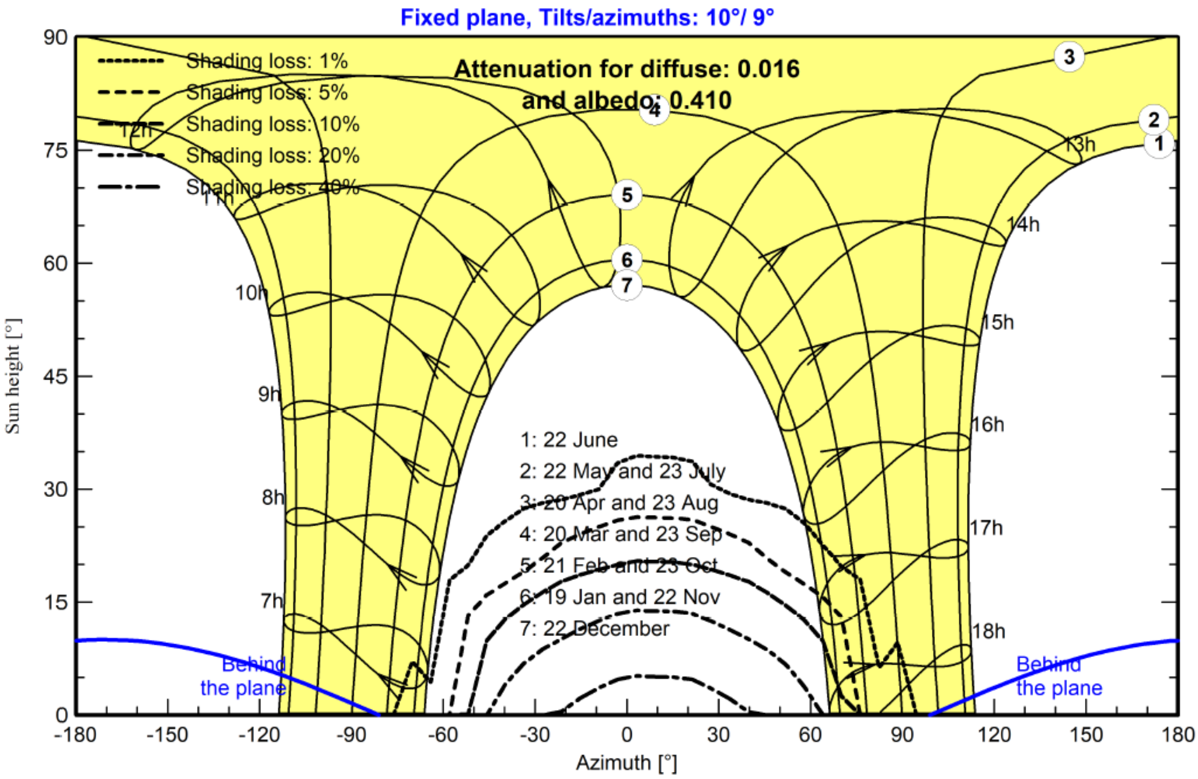
In this era of sustainability and renewable energy, Rajapalayam LPA stands at the cusp of a transformational journey towards a greener and more energy-efficient future. The focus on RTPV systems is not only a pragmatic choice but also a strategic one that can lead to long-term benefits for the community and the environment. With the right initiatives and public support, Rajapalayam LPA can lead the way in RTPV deployment and contribute to a more sustainable energy landscape.

Annexure I

Detailed reports from PVSyst for a selection of residential buildings

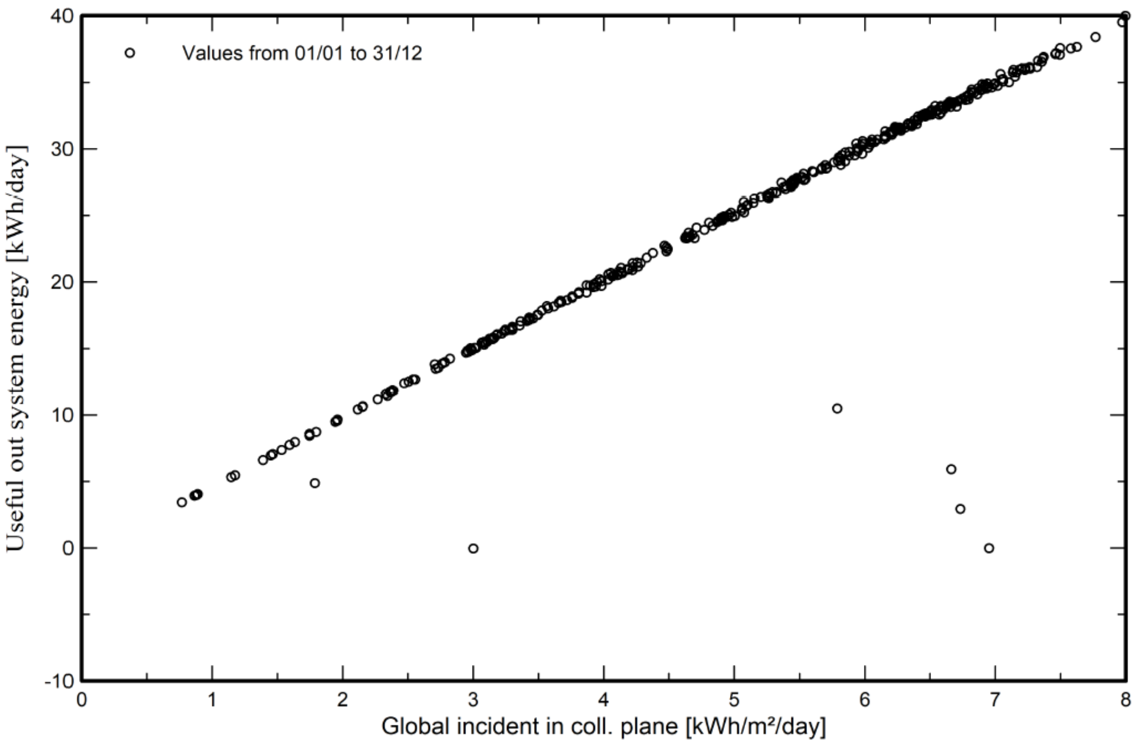
Iso-shadings diagram

Orientation #1

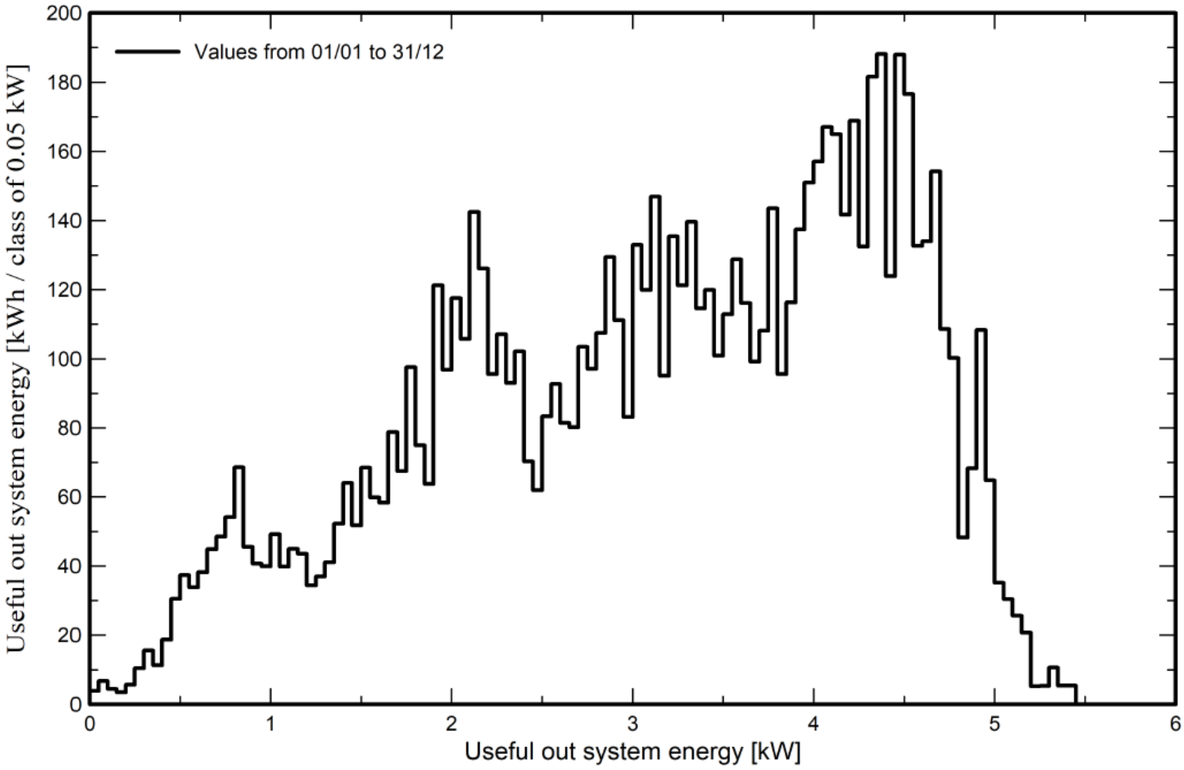


Predef. graphs

Daily Input/Output diagram



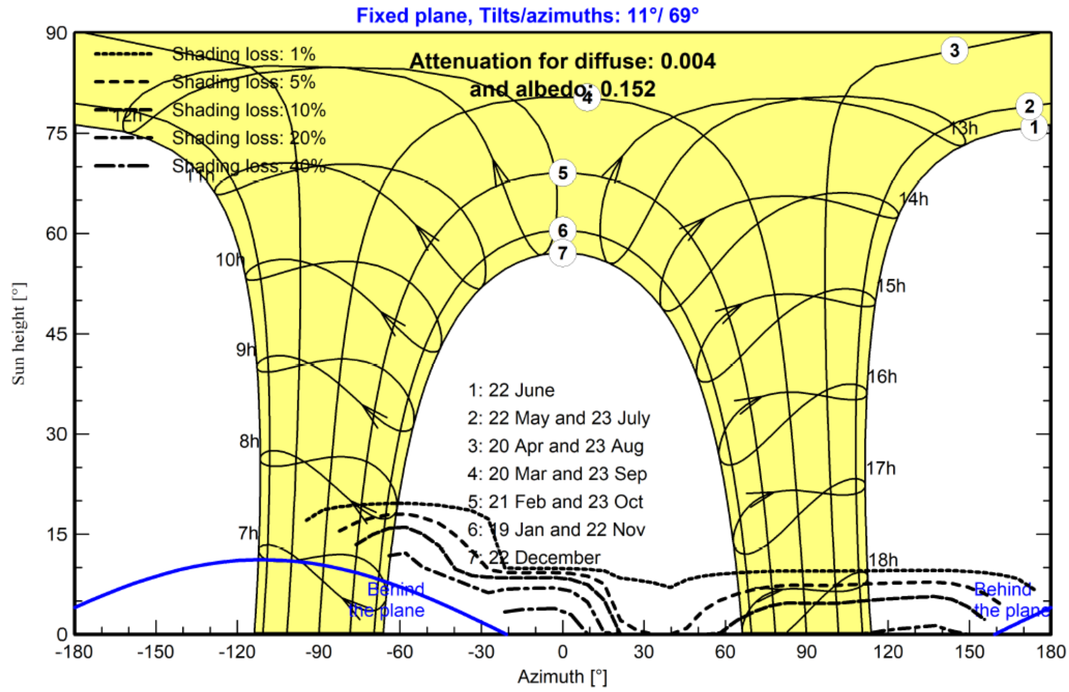
System Output Power Distribution



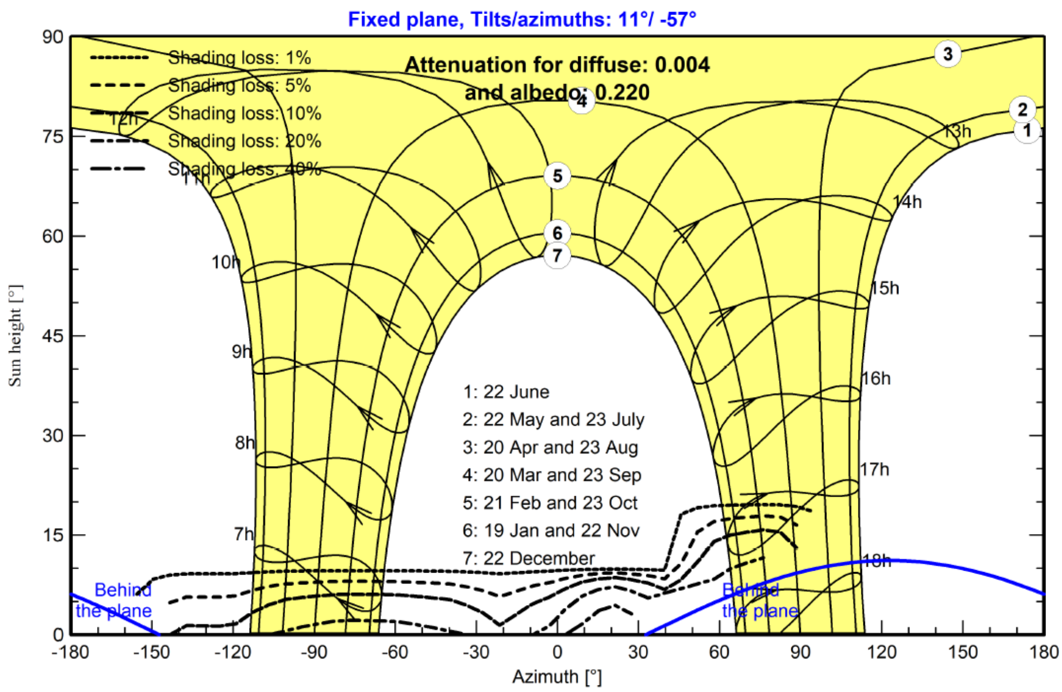
Detailed reports from PVSyst for a selection of industrial buildings

Iso-shadings diagram

Orientation #1

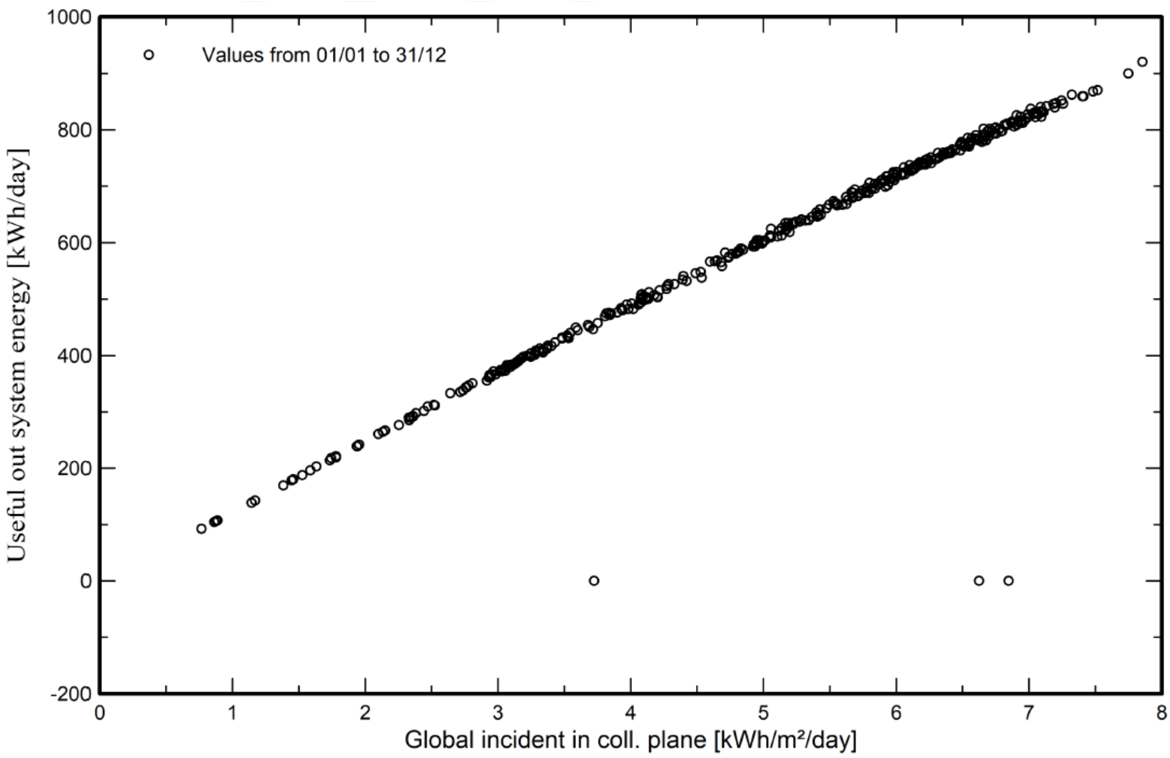


Orientation #2

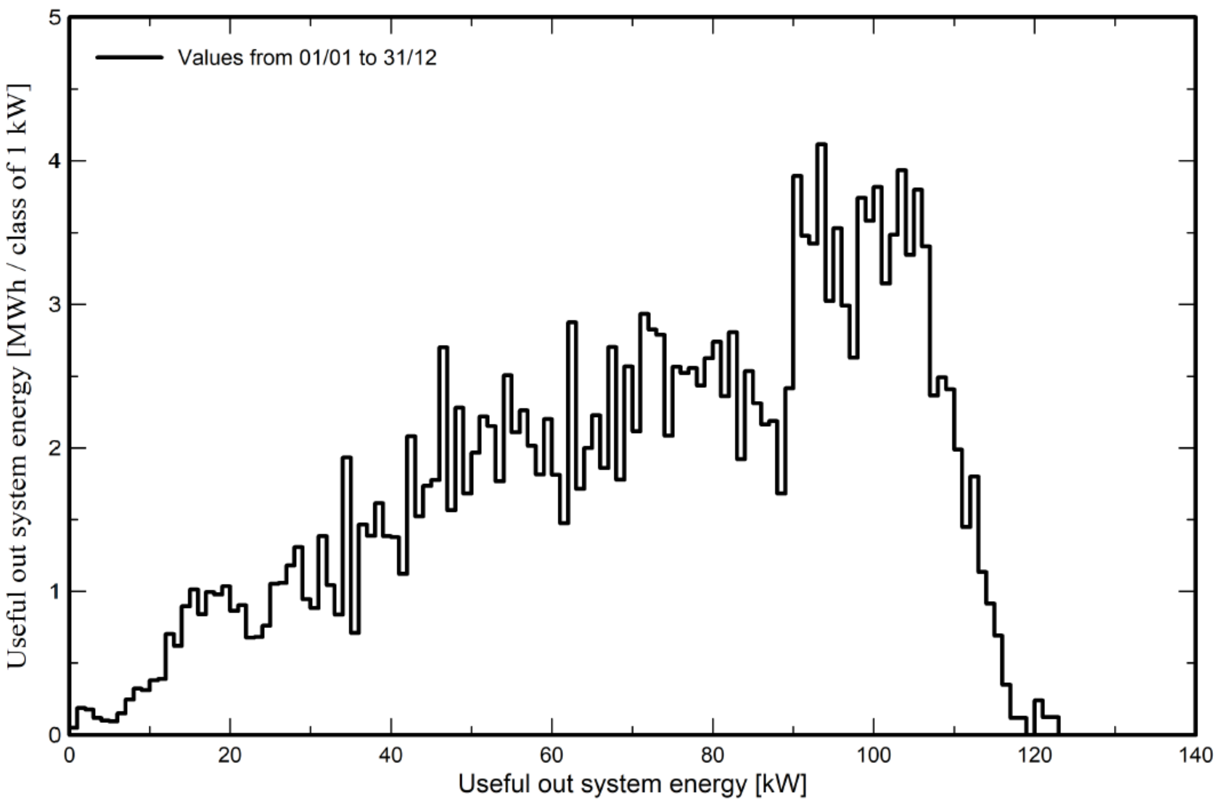


Predef. graphs

Daily Input/Output diagram



System Output Power Distribution



Annexure -3

Avoided Emissions due to Enhancement of Non-Motorized Transport Infrastructure and Public Transport

The avoided emissions due to lesser use of private vehicles on account of strengthening the non-motorized transport infrastructure, such as, pedestrian pathways, cycle lanes, etc and enhancing public transport, would mean behavioural change and hence these possible/probable avoided emissions are accounted in the 'Aggressive with Behavioural Scenarios' given in the relevant sections of the plan. In our view, these changes could potentially result in Rajapalaym LPA achieving carbon neutrality either by or well before 2038 as given in the 'Aggressive with Behavioural Scenarios'.

Table A2. Impact of shifting private vehicles to NMT on GHG emissions abatement:

% of vehicles shift to NMT	Total Fuel Avoided (Million Litres)	Total Emissions avoided (kTCO2e)
10%	1.09	2.84
20%	2.19	5.69

Annexure -4

Indicative funding avenues for the estimated financial requirement for 2027

This document is to be read in tandem with the Rajapalayam 2027 Vision (given in section 5 / page 54). The total costs given for each recommendation is for the target set for 2027.

(i) Green spaces and carbon sequestration | Cost: 26.5 Crores

a. Restoration and afforestation: (a) 111 ha, 40% of Sanjeevi Malai | Cost estimated: 2.00 crores
b. Restoration and afforestation of 422 ha of the remaining reserved forest | Cost estimated: 2.00 crores
c. Creation of Eco-park at the base of Sanjeevi Malai on 44 acres of Bhoomidan lands | Cost estimated: 11.00 crores
d. Increasing tree cover in non urban zone | Cost estimated: 10 crores
e. Vertical gardens at strategic locations | Cost estimated: 1.5 crores

Funding Avenues:
Compensatory Afforestation Fund Management and Planning Authority (CAMPA), Nagar Van Yojana, as part of CSR Activities and other listed schemes

Compensatory Afforestation Fund Management and Planning Authority (CAMPA)[1]:
State CAMPA to submit the Annual Plan of Operations (APO) to get funds and engage the local communities in afforestation, soil water conservation and forest protection activities.

Nagar Van Yojana[2]:
Promotes urban forestry by creating urban forests/parks. Grants limited to 50 ha, with funding up to ₹4 lakhs per hectare. At least two-thirds of the area must be under tree cover and may include biodiversity parks, butterfly conservatories, smriti vans, herbal gardens, and waterbodies.

Rashtriya Krishi Vikas Yojana (RKVY)[3]:
The Agroforestry component under RKVY provides up to ₹50 lakh for establishing nurseries to produce Quality Planting Materials, with 100% assistance for government agencies and 50% for private agencies.

National Afforestation Programme (NAP): increase forest cover and improve livelihoods of forest-fringe communities, with funding shared 60:40 between the Centre and States.

In future, the Green Credit Programme[4] may also be a source of funding:
For plantation on identified degraded land of over 5 ha, subject to minimum density of 1100 trees/hectare. 1 credit per tree planted.

1 https://pib.gov.in/PressReleasePage.aspx?PRID=1906384
2 https://mpforest.gov.in/img/files/Nagar_Van_Scheme_Guidelines_English.pdf
3 https://www.myscheme.gov.in/schemes/agroforestry
4 https://d28fok4odypdh0.cloudfront.net/revised-om-clvb6dqvu00120iym5b4e0wse.pdf

Green Tamil Nadu Mission (GTM)[5]:
Stakeholder contributes 51% of total cost and rest can be from GTM fund.
Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA): Eco-Park may also source some funding from MNRE schemes as the Eco-Park will install/display RE installations at large scale

Namakku Namae Thittam[6]:
For creation and maintenance of community infrastructure this scheme improves the self support mechanism and enhances public participation. The public contribution for any identified work (except renovation of water bodies) would be one third of estimated value and for works related to renovation of water bodies the public contribution would be 50%. There is also no upper limit for public contribution.

(ii) Municipal Solid Waste Management | Cost: 8.4 crores

a. Segregation at source through colour coded bins | Cost estimated: 4.5 crores
b. Waste processing stations | Cost estimated: 2.00 crores
c. EVs for waste collection and transfer | Cost estimated: 0.4 crores
d. Community based composting/ vermicomposting units | Cost estimated: 1.5 crores

Financial Avenues:
Municipality budgets, Swachh Bharat Mission, Viability Gap Funding, adopting public private partnership (PPP) model and using CSR funds and other relevant schemes (listed below).

Swachh Bharat Mission-Urban (SBM(U)) 2.0[7]:
For Urban Local Bodies (ULBs) with a population of less than 10 lakh, central share per unit is 50% and minimum state share is 33% and remaining 17% balance fund can come from 15th Finance Commission funds, ULB share or private sector share.

Viability Gap Funding (VGF) scheme[8]:
Under revamped VGF - PPP mode for infrastructure projects - Up to 60% of total project cost (30% each from Central and State Governments

Tamil Nadu EV Policy 2023[9]:
Aims to accelerate adoption of EVs in Tamil Nadu. The government incentivise commercial vehicles by providing a maximum incentive of Rs 40, 000 for commercial e-3 Wheelers (autos/ Light Goods Carriers) (maximum 15,000 vehicles/year) and Rs 1,50,000 for e-4 Wheelers (Cabs/ Goods Vehicles) (maximum 3000 vehicles/year) etc subject to conditions.

National Mission for Sustainable Agriculture[10]:
50% of cost subject to a limit of Rs. 5000/- per ha and Rs. 10,000 per beneficiary.

5 https://greentnmission.com/uploads/GOs/npt.pdf
6 https://www.tnurbantree.tn.gov.in/namakku-naame-thittam/
7 https://sbmurban.org/storage/app/media/pdf/swachh-bharat-2.pdf
8 https://www.pppinindia.gov.in/vgfguidelines
9 https://investingintamilnadu.com/DIGIGOV/StaticAttachment?AttachmentFileName=/pdf/poli_noti/TN_Electric_Vehicles_Policy_2023.pdf
10 https://nmsa.dac.gov.in/pdfdoc/NMSA_Guidelines_English.pdf

(iii) Plastic Waste Management | Cost: 1.2 crores

a. Use of plastic waste for road construction | NA
b. Handicrafts from non-recyclable plastic waste and eco-friendly alternatives to single-use plastics | Cost estimated: 1.00 crore
c. Plastic waste palletization | Cost estimated: 0.2 crore

Financial Avenues:
Municipality budgets, Swachh Bharat Mission, using CSR funds and other relevant schemes

SBM(G)[11]:
Rs.16.00 Lakhs to establish Block Level Plastic Waste Management Units run by SHGs to process plastic waste into value-added products like paver blocks and park benches.

(iv) Wastewater Management | Cost: 22.5 crores

a. Enhance UGD connection - Cost to be assessed | 246.99 crores has been earmarked for Rajapalayam Municipality and work is under progress[12]
b. DEWATS along with simplified sewer system | Cost estimated: 4.5 crores
c. Twin-pit septic tanks and FSTP at village level | Cost estimated: 18 crores

FInancial Avenues:
Municipality budgets, Swachh Bharat Mission - Gramin (SBM(G))

SBM(G)[13]:
Rs.3 lakh for Gram Panchayats for Community Managed Sanitary Complex (CMSC) at village level. Additionally a subsidy of Rs.12,000 per household for twin pit toilets (60% from centre and 40% from the State)

(v) Sustainable Agriculture Practices | Cost: 8.1 crores

a. Use of organic fertiliser instead of urea | Cost estimated: 5.68 crores
b. Diversion of land under rice cultivation to millets | No direct cost involved
c. Mixed cropping and multilayer cropping of rice cultivated area | NA
d. Shifting rice cultivation water regime from continuous flooding to multiple aeration along with System of rice intensification | Cost estimated : 1.22 crore
e. Mini weather monitoring stations to forecast extreme weather conditions | Cost estimated: 0.2 crore
f. Livestock feed additives to reduce methane emissions | Cost estimated: 1 crore

Financial Avenues:
National Mission for Sustainable Agriculture, Paramparik Krishi Vikas Yojana, National Mission on Natural farming, Kalaignarin All Village Integrated Agriculture Program, Mission on Sustainable

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11https://swachhbharatmission.ddws.gov.in/sites/default/files/Guidelines/Amendment_to_para_regarding_funding%20provision_for_SWM_and_GWM.pdf

12 https://www.tnurbantree.tn.gov.in/under-ground-drainage-scheme/

13https://swachhbharatmission.ddws.gov.in/sites/default/files/Guidelines/Amendment_to_para_regarding_funding%20provision_for_SWM_and_GWM.pdf

Dryland Agriculture, Chief Minister's Mannuyir Kaathu Mannuyir Kaappom Scheme, GOBAR-dhan scheme, Krishi Vigyan Kendra,

National Mission for Sustainable Agriculture (NMSA)[14]:
organic farming - up to 50% of the cost of organic inputs, up to a limit of Rs 5,000 per hectare and Rs 10,000 per beneficiary
Vermi-compost units - up to 50% of the cost, up to a limit of Rs 50,000 per unit

Paramparik Krishi Vikas Yojana (PKVY)[15]:
provides end-to-end support to organic farmers i.e. from production to processing certification and marketing by a cluster approach. States are provided financial assistance of 39000/ha for 3 years for on-farm and off-farm organic inputs, marketing, packaging, branding, value addition, certification and residual analysis

National Mission on Natural farming[16]:
Centrally sponsored scheme with an overall outlay of ₹2,481 crore. The Mission has a target to initiate 1 crore farmers to natural farming spreading over 7.5 Lakh ha land.

Kalaignarin All Village Integrated Agriculture Program (KAVIADP)[17]:
Funds of up Rs 227 crore is available and will benefit over nine lakh farming families in 1,997 village panchayats across the state.

Mission on Sustainable Dryland Agriculture (MSDA)[18]:
to transform dry land into fertile land for growing millets.

Chief Minister's Mannuyir Kaathu Mannuyir Kaappom Scheme (CM MK MKS)[19]:
to improve soil fertility by distributing green manure seeds to farmers.
-Distribution of Green Manure Seeds @50% Subsidy (Rs.1000/acre/farmer)
-Distribution of Vermibeds at 2 vermibeds / farmer at 50% subsidy

GOBAR-dhan scheme[20]:
Rs.50.00 Lakh per district to produce biogas and bio slurry from agri waste

Krishi Vigyan Kendra (KVK)[21]:
KVKs to support capacity development of location specific and modern agriculture technologies.

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14 https://pib.gov.in/newsite/PrintRelease.aspx?relid=112716

15 https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2082783

16 https://pib.gov.in/PressReleasePage.aspx?PRID=2077094

17https://aed.tn.gov.in/en/schemes/special-schemes/kagovvt/https://www.thehindu.com/news/national/tamil-nadu/stalin launches-kalaignarin-all-village-integrated-agriculture-development-programme/article65453086.ece

18 https://www.niti.gov.in/sites/default/files/2023-06/Report-on-Promoting-Best-practices-on-Millet-26_4_23.pdf

19 https://www.tnagrisnet.tn.gov.in/people_app/GoScheme

20 https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1941122

21https://kvk.icar.gov.in/aboutkvk.aspx#:~:text=The%20KVK%20scheme%20is%20100,%28NGOs%29%20working%20in%20 Agriculture

(v) Energy | Cost: 274 Crores

i) Installing Solar rooftop across residential households:

Policy:
PM Surya ghar Muft Bijli Yojana and prioritizing rooftop solar on all government building (MNRE mandate for 2025):

Under the PM-Surya Ghar Muft Bijli Yojana, the proposed subsidies are:

Average monthly electricity conumption (units)	suitable rooftop solar plant capacity	Subsidy Support
0-150	1-2kw	Rs30,000 to Rs 60,000
150-300	2-3kw	Rs60,000 to Rs 78000
>300	Above 3kw	Rs78,000

A 3 kWp rooftop plant could cost somewhere between 1.5-1.8 lakh. After subsidy, the financial burden to the consumer is 0.8-1 lakh which could be recovered within 3-4 years (considering TN domestic tariff structure) through electricity savings.
Therefore, a rooftop plant is economically viable and could potentially be privately or self funded and does not require further state capital support.

ii) Installation of solar pumps to replace existing diesel pumps in the LPA under PM KUSUM scheme (Component B)
Under the PM-KUSUM scheme, 30% of the capital cost of decentralized solar pump procurement is covered under the scheme.

iii) Addition of 2 wheeler, 3 wheeler and Electric buses on priority:
As per the Tamil Nadu EV Policy, subsidies are applicable only for commercial two-wheelers. Therefore, the cost of electrifying 6,500 private electric two-wheelers must be sourced from private funds.
For the electrification of 25 buses, the TN EV Policy provides an incentive for the upfront purchase of 300 buses across the state, with a ceiling of ₹10 lakh per bus.
For the electrification of 450 three-wheelers proposed (till 2027) in the plan, the TN EV policy provides a subsidy of ₹40,000 per commercial 3 wheeler vehicle, applicable to the first 15,000 vehicles.

Notes

Notes

TNGCC
Tamil Nadu Green Climate Company

VASUDHA FOUNDATION
Green ways for a good earth!

D-2, 2nd Floor, Southern Park, Saket District Centre, New Delhi-110017, India

www.vasudha-foundation.org

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