Carbon Neutral and Climate Resilient Ladakh

A strategy document- Action plan and Roadmap

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The Energy and Resources Institute

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Introduction

Ladakh is a mountainous region and a Union Territory (UT) in the north India, in the area known as the Trans-Himalaya. Leh is the largest urban zone having a population of 30,870 (census 2011). Compared to the national average of 69% Ladakh has a significantly higher share of the rural population of 89%. Nearly 58% of the total population depend on agriculture indicating that the region agriculture provides the main source of the livelihoods. The average energy consumption per capita per day is 9800Kcal compared to the national average of 12800 kcal.

Tourism has been an emerging sector of the region, creating employment opportunities and income generations not just for the locals but for the migrants as well. Further with the elevation of Ladakh as a separate UT, it is anticipated that the region will attract even more attention and attraction as a destination to explore new opportunities primarily in tourism sector. With growing economic activities energy demand too will increase in the form of electricity and transportation fuels. Because of the absence of renewables, to cater to the increasing demand for fuels, the dependence on fossil fuels will rise which will not only increase local pollution in the form of particulate matter emission that can pose serious health impacts, it also leads to CO2 emission, the primary cause of global warming. The region however, at the same time offers unprecedented opportunities in decoupling the fossil fuel consumption and economic growth while ensuring socio-economic development. Thus, it is imperative to have a climate resilient and resource efficient green development strategy for the region which supports and balances economic growth and social inclusiveness and preserves rich ecological diversity.

In this context, the objective of the project was to prepare an all sector encompassing carbon neutral action plan (CNAP) for Ladakh. The CNAP takes a systematic top-down and bottom-up approach for economy wide decarbonisation of Ladakh. The CNAP identifies a strategic and ambitious alternate scenario envisioning the accelerated efforts for economy-wide decarbonisation.

Key Findings

The carbon neutral strategy for Ladakh required a sectoral assessment of potential environmental related challenges which disrupts economic growth and rich ecological diversity in the region.

Residential

The residential sector in Ladakh accounts for the maximum consumption of energy and water resources.

- The total energy demand of residential sector will decrease by 9% in the baseline scenario compared to 33% in the alternate scenario due to the adoption of various demand side management techniques.
- The overall emissions from the sector are estimated to be 65 kilotons CO2 equivalent in 2019 that are estimated to increase to 91 kilotons CO2 equivalent in 2050 in the baseline scenario, however reduce by 32% in the alternate scenario.

Transport

Land transport is a major carbon emitter of the region due to the rising tourism related activities. The estimated number of registered vehicles will increase by more than four times by 2050 in the UT.

- The total energy demand will increase from 1676 thousand gigajoules in 2019 to 6260 thousand gigajoules in 2050 under the baseline scenario, however this will be reduced by more than 30% under the alternate scenario.
- The electrification of vehicular fleet has also been considered under the future scenarios that can increase the current electricity demand from 0.4 million MWh to 2 million MWh.
- The overall emissions from the transport sector will increase from 168 kilotons CO_2 equivalent in 2019 to 647 kilotons CO_2 equivalent in 2050 under the baseline scenario however it will decrease by 47% in the alternate scenario.

Commercial

The major categories considered under the commercial sector are the hotels, borewells and other buildings, that include public services, commercial establishments, offices and restaurants.

- The total numbers of hotels are estimated to increase by more than three times by 2050 with an annual average growth rate of more than 7%.
- The total energy demand is estimated to increase from 562 thousand gigajoules in 2019 to 2090 thousand gigajoules in 2050 under the baseline scenario, however this will reduce by 10% in the alternate scenario.
- The total emissions are estimated to be 34 kilotons CO_2 equivalent in 2019 which are estimated to increase to 121 kilotons CO_2 equivalent in 2050 under the baseline scenario however these will reduce by 26% under the alternate scenario.

Urban Management

Under urban management, two categories have been included, water and street lighting.

- The total energy demand of water supply and street lighting together is estimated to be 6.6 thousand gigajoules in 2019 which will increase to 24 thousand gigajoules in 2050 under both the baseline and alternate scenario. This is because the overall energy demand will rise but the share of diesel in the fuel mix will fall and the share of renewables sourced electricity will increase.

- The total emissions are estimated to be 0.2 kilotons CO_2 equivalent in 2019 which are estimated to increase to 0.7 kilotons CO_2 equivalent in 2050 under the baseline scenario however these will remain constant under the alternate scenario.

Defence

Ladakh being an important location for the presence of defence forces, poses a lot of infrastructural requirements for them. These basic requirements for the defence include transportation, cooking, space heating and lighting.

- The total energy demand is estimated to increase from 2106 thousand gigajoules in 2019 to 2972 thousand gigajoules in 2050.

Electricity

Electricity in the region is majorly sourced from DG sets and hydro. Currently the presence of solar based electricity is miniscule. The current total installed capacity is 161 MW.

- The total installed capacity under the baseline scenario is estimated to be 1850 MW in 2025 which will increase to 7850 MW in 2050. However, under the alternate scenario, the share of solar is estimated to be higher than the baseline and the total installed capacity will be 25GW. Also, under the alternate scenario, energy storage of 100MWh is considered in 2050.

Agriculture

The agriculture sector is an important source of GHG emissions namely methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2).

- The total emissions are estimated to be 163 gigajoules CO_2 equivalent in 2017 which are estimated to increase to 264 gigajoules CO_2 equivalent in 2050 under the baseline scenario. However, these are estimated to decline by 30% under the alternate scenario.

Net GHG Accounting and State of Carbon Neutrality

The total carbon emissions under the baseline scenario increased from 563 kilotons CO_2 equivalent to 1334 kilotons CO_2 equivalent in 2050 and under the alternate scenario these will reduce by 37%. According to the existing carbon stock which is 890 kilotons CO_2 equivalent, Ladakh will become net GHG emitter post 2035, however it will continue to be carbon negative till 2050 if the strategies under the alternate scenario are adopted.

Key Recommendations

Opportunities exist across various thematic areas that have the potential to bring benefit in reducing emission and ecological footprint in various sectors. The strategies recommended under the various thematic areas are:

Hydrogen as a resource for supporting energy transition

Transition to a hydrogen-based economy will require a phase wise implementation strategy and to initiate, there is a need to undertake pilot interventions. For that matter, CSR funds from relevant public and private sector undertakings can be used for putting various demonstration projects. Further, department of science and technology in partnership with key research institutions and universities of higher learning can set up projects in selected locations in Ladakh.

Climate resilient sustainable agriculture practices

The overall efficiency, resilience, adaptive capacity and mitigation potential of the production systems in Ladakh can be enhanced by an integrated approach on climate resilient sustainable agriculture practices combined with indigenous knowledge and modern organic methodologies. This will require adequate funding for research into agro-ecology and agro-forestry. The use of composted manures in agricultural soils should be encouraged for which a greater policy focus would be required. The adoption of low-cost passive solar greenhouses needs to be devised as well which is a way of clustering organic farms.

Steering towards sustainable urban development services

For urban management it is imperative to implement strategies in sectors pertaining to water management, construction and solid waste management. For water management, water meters need to be installed, piped connections to households need to be provided, promotion of sustainable habitats, green certification system and promotion of waste management practices is required. In order to regulate water use in commercial establishments, taxes may be levied after a permissible limit by relevant authorities. Subsidies might be provided for new constructions which have been certified by green rating agencies such as GRIHA. Tax concessions might also be provided to establishments which have installed water metering systems. Thus, there is an immediate need for an overarching policy to promote sustainable water use management in Ladakh and policies to promote use of sustainable building materials also need to be framed.

Greening transport sector in Ladakh

Expanding the commitment to cleaner fuels, UT should replace the private transport vehicular fleet and public services vehicles with HEVs in near future and complete EVs gradually. Hydrogen as a fuel for defence transport and other requirements has plenty of scope to reducing the regions emissions. Fleet modernization can also significantly reduce the emissions for which The UT can consider offering 50% exemption on excise duty and road tax on purchase of new vehicles. For the promotion of the use of public transport, last mile connectivity needs to be ensured which can be done by battery enhanced cycles. Roadway pricing could be imposed which can be implemented in number of ways. These include charging tolls, cordon pricing as a charge to enter or exit a particular location.

Harnessing renewables for climate friendly electricity sector

It is important to provide open, transparent and dependable conditions for RE players with the provision of ease of doing business, flexible labor markets, and safeguard of intellectual property rights to promote renewables in the UT. Establishment of an investment promotion agency, infrastructure for potential investor, and mechanisms like Power Purchase Agreements (PPA) and Feed-in-Tariff (FiT) will play an influential role in restricting uncertainties of developers and investors.

Also, there should be strong local level approval system along with an effective indigenous utility in the region and policy on energy storage should be developed. Thus, the government should provide enough budget allocations for RE sector. With the special focus on R&D, the surplus fund for R&D should be allocated along with the provision of monitoring the budget allocation.

Adoption of Sustainable Tourism practices

Sustainable tourism is an important aspect because of the growing impacts of tourism on the sensitive ecology of the region. Homestays and guesthouses should be encouraged as primary accommodations in the region. Non-motorised and electric transportation should be incentivized, metering tools for piped and pumped water should be introduced to enhance monitoring, the tourist movements in fragile ecological zones should be regulated. Further solar panels should be introduced in hotels, dry toilets should be encouraged and tourists should be incentivized to adopt sustainable practices thus promoting behavioral transformations in tourists.

Chapter 1: Introduction

Ladakh embodies the environment in its most pristine form. Ladakh has for its remote mountain beauty and distinct culture has become synonymous with biodiversity protection in India. Ladakh forms the highest plateau in the country with much of land above 3,000 metres. It extends from the Himalayas to the Kunlun Ranges and includes the upper Indus River valley. Ladakh, comprising of Leh and Kargil districts formed in 1979 and having an average population density of 4, is one of the least populated areas in India. For centuries, Ladakh has enjoyed a culture in which humans, wildlife and wilderness have been living in a certain level of harmony.

Despite extreme climate and rough terrain, Ladakh's unique landscape, traditional culture, and unpolluted environment and opportunity for adventure tourism, has been attracting thousands of tourists both from home and abroad since the 1970s. The region was considered as an ideal area of biodiversity protection in India. In the early1980s, the first high altitude Hemis National Park was created. With a total area of around 4400 km2, it became the largest national park in South Asia

Ladakh has a total surface area of 59,146 km2 which accounts for 1.7% of the total surface of the country. As per 2011 census, the total population of Ladakh has been reported at 274,289 with an estimated household of 48,000 (approx.). Leh is the largest urban zone having a population of 30,870 (census 2011). Compared to the national average of 69% Ladakh has a significantly higher share of the rural population of 89%. Nearly 58% of the total population depend on agriculture indicating that the region agriculture provides the main source of the livelihoods. The average energy consumption per capita per day is 9800Kcal compared to the national average of 12800 kcal.

As mentioned above, tourism is an important industry where it creates employment opportunities and income generation for many. Although it has been a part of Jammu and Kashmir for quite long time, however, the Autonomous Hill Councils of Leh and Kargil played an important role towards local development. The Hill Councils worked with the village panchayats in taking decisions on local economic development, education, land use, taxation, healthcare, and local governance.

With the Jammu and Kashmir Reorganisation Act, coming into force in August 2019, the state of Jammu and Kashmir was divided into two union territories, namely the union territories of Jammu and Kashmir, and that of Ladakh. With this elevation as a Union Territory with its two existing districts of Leh and Kargil, it is anticipated that the region will attract even more attention and attraction as a destination to explore new opportunities primarily in tourism sector. With growing economic activities energy demand too will increase in the form of electricity and transportation fuels. To cater to the growing demand, Ladakh has an installed capacity around 143 MW that includes Hydel plants, Diesel gen-sets, Solar Hydroelectric and few solar PV micro grids. Absence of renewable energy deployment may increase dependence on fossil fuel based DG sets that will pose serious environment threat. Increase in civil and defence mobility demand will too jack up consumption of petrol and diesel, and the consequences need no mention. Provision of enhanced and improved urban services in the form of water supply, waste management and construction will also require energy. Dependence on fossil fuel not only increases local pollution in the form of particulate matter emission that can pose serious health impacts, it also leads to CO_2 emission, the primary cause of global warming. The region however, at the same time offers unprecedented opportunities in decoupling the fossil fuel consumption and economic growth while ensuring socio-economic development.

Recently, India's Hon'ble Prime Minister Mr, Narendra Modi shared his vision for the region in promoting solar energy, connectivity (road, rail, air, telecom and electric grid), organic farming, Kesar revolution, enhancing production of handicrafts through technology, making the world-class centers of spiritual/eco and adventure tourism, and as well as developing export capabilities for certain products in the region.

The imperatives of climate resilient and resource efficient green development strategy for the region which supports and balances economic growth and social inclusiveness and preserves rich ecological diversity is evident from the anticipated threats that the current growth may have in the region

Towards this vision and objective, The Energy and Resources Institute (TERI), was requested by NITI Aayog to prepare a carbon neutral strategy for Ladakh.

Based on extensive interaction with relevant stakeholders (that included represented from the administrative departments, civil society organizations, associations, etc), review of literatures and assessment of secondary data, TERI has drafted this strategy document that not only provides an overview of the key economic sectors and the associated challenges it provides comprehensive strategies that will facilitate a carbon neutral transition for Ladakh.

Chapter 2: Approach to develop carbon neutral roadmap

The objective of the project was to prepare an all sector encompassing carbon neutral action plan (CNAP). The CNAP takes a systematic top-down and bottom-up approach for economy wide decarbonisation of Ladakh. The CNAP identifies a strategic and ambitious alternate scenario envisioning the accelerated efforts for economy-wide decarbonisation. The Ladakh CNAP is structured to sector specific emissions, then to linkages with adaptation at different levels of intervention i.e. electrification, technology switch, technology upgradation, efficiency improvement, etc.

The development of the strategic action plan was informed by number of sources (i.e. UT policies, and service delivery plans), future municipal considerations and input from government stakeholders. Further, the adaptation to CNAP will require the social, environmental and economic considerations, with governance and monitoring and evaluation for CNAP progress.

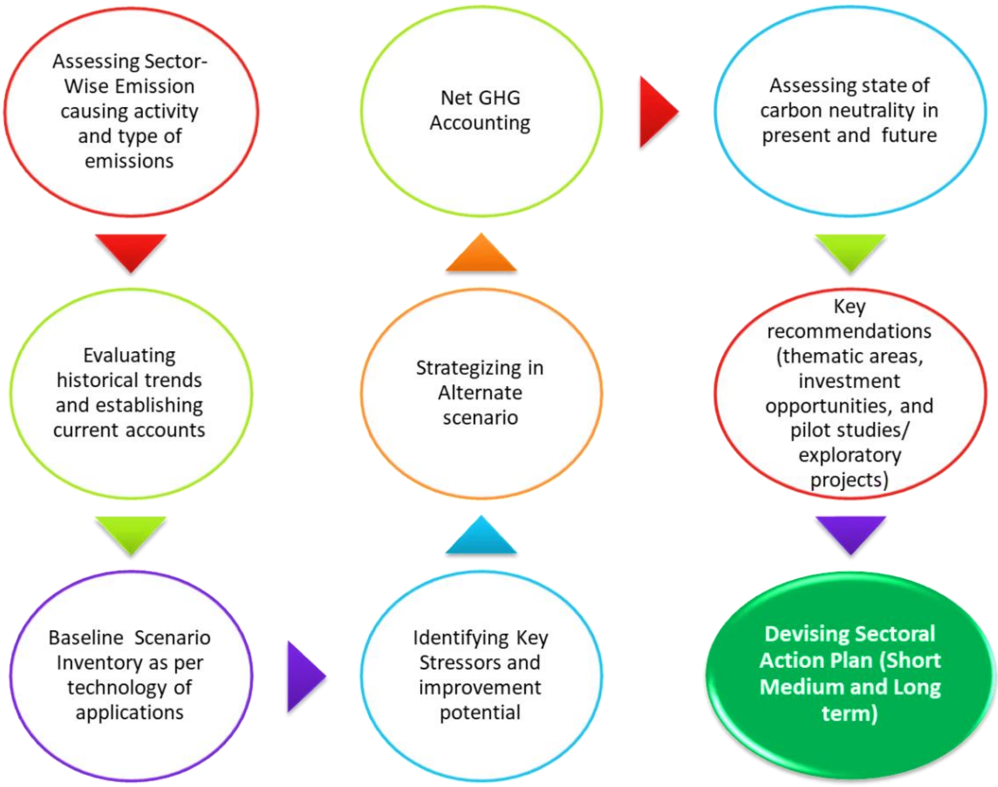


Figure 1: Project Approach

- **Step 1:** ***Assessing sector-wise emission causing activities and type of emissions***
  The assessment was undertaken to understand where the emissions are coming from in order to develop effective solutions and mitigation strategies.
  It includes the electricity and other fuels used in the buildings/ households, commercial and industrial units, agriculture, fuel used by fleet vehicles and electricity generation plants, and waste generated. These sectors were further disaggregated to the energy intensive activities and the usage share of diversified fuel which are contributing to UT's GHG emission profile.

- **Step 2:** ***Current Accounts and evaluating historical trends***
  The identification of energy intensive activities is followed by the data collation to establish current accounts for Ladakh. The comprehensive set of data has been developed both from secondary literatures and reports as well as primary interaction with the district and state departments. The historical trends are than established for the available time-series data.

- **Step 3:** ***Baseline Inventory from Technological Database***
  The UT's carbon emissions has been estimated based on the technological database (TED database of LEAP model) i.e. emission factors are used based on the technology of fuel usage. The baseline inventory of total energy demand, and GHG emissions balance sheet were prepared up to 2050 based on the policy priorities in the region, changing fuel usage trends and perceived increase in tourist footfall in future. The GHG emissions that are covered under this strategy development are those resulting from the usage of energy and fuel and not the whole of life cycle emissions of creating and maintaining infrastructure and projects.

- **Step 4:** ***Identifying Key Stressors and improvement potential***
  The inventory preparation is followed by the identification of activities which has the increasing share of contribution to the overall GHG emissions of Ladakh under baseline scenario. The activities which are currently based on low efficient technology or the activities which has the potential of emission reduction are identified. Potential interventions have been selected based on their feasibility and ease of implementation.

- **Step 5:** ***Strategizing in Alternate scenario***
  The alternate scenario with low emission development is strategized for each sector underpinned by range of key actions to be implemented within a short, medium and long-term time frame to achieve emission reductions.

  The strategies are broadly developed considering the demand and supply side of energy usage. Improvement in mix of car fleet, opportunities for increasing yield in agriculture sector, efficiency improvement at consumption level and supply of cleaner fuel for heating and electricity requirements are the key areas of focus.

The carbon neutral framework in figure 2 below provides a way to reduce energy used and greenhouse gas emissions associated with the UT's economy.

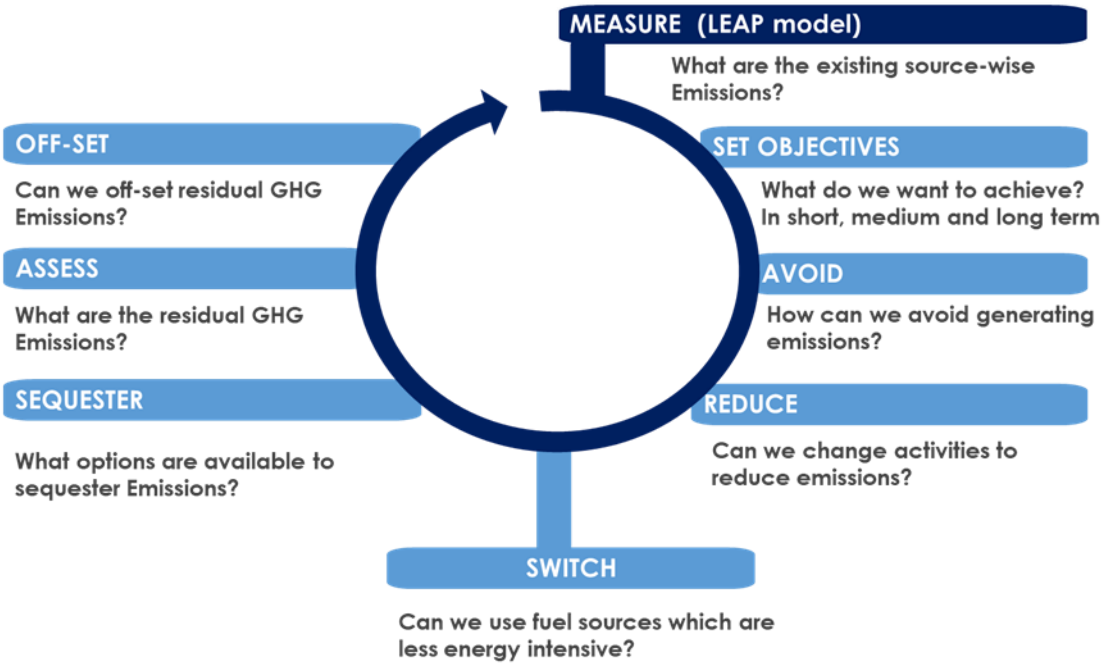


Figure 2: Carbon neutral framework

- **Step 6:** ***Net GHG Accounting***

  The accounting of emissions sources and sinks is undertaken to estimate the net GHG balance of the region. The gross emissions are accounted attributed to each sector of the region's economy. And the total removal from Land Use, Land Change and Forestry (LULUCF) is incorporated in the accounting system. The total net GHG flow from LULUCF in a defined base year and given year is accounted for the region's GHG balance.

- **Step 7:** ***Assessing state of carbon neutrality in present and future***

  To substantiate and claim terrain a carbon neutral region, the state should be linked to a particular and specified time period. The state of carbon neutrality is assessed for base year and for emissions in future. It helps to understand the quantum of difference between the carbon sink and emissions in a specified year.

- **Step 8:** ***Key recommendations (thematic, investment opportunities, and pilot studies/ exploratory projects)***

  The recommendations and long term strategies are provided in order to develop a resilient infrastructure that have cross sectoral implications. The region should look forward with the broad focus on these thematic strategies that can be implemented through set of multiple mechanisms. The concerned regional department can build on the vision of attaining these targets with the identification of scalable mechanisms that can drive the transition in the region. Special emphasis has been provided to ensure that there is greater adaptability to the adverse impacts of climate change by fostering climate resilience in certain sectors including agriculture and water. These measures are intrinsically linked to sustainable development, as they reduce the risk to lives and livelihoods and increase the resilience of communities

- **Step 9:** ***Devising Sectoral Action Plan (Short Medium and Long term)***
  The CNAP is planned by identifying policy and other implementation options in the region. It includes the range of measures including the field of investment promotion, spreading informational awareness, and the mechanisms to drive efficient use of energy, and accelerating the programs for sustainable agriculture, transport, and electricity.

Chapter 3: Sector Specific Activities and Challenges and mitigation potential

The imperatives of climate resilient and resource efficient green development strategy for Ladakh requires a sectoral assessment of potential environmental related challenges which disrupts economic growth and rich ecological diversity in the region. The major sectors which have been considered for assessment include the Residential sector, Energy, Transport, Commercial, Agriculture & Forestry and Urban Management spaces. All these sectors are heavily dependent on water and are energy intensive. The following sub-sections exhibit the present state and key challenges faced by these sectors which ultimately lead to increased emissions.

3.1 Residential

The residential sector in Ladakh accounts for the maximum consumption of energy and water resources. Although there are no concrete estimates on the consumption of water by the residents, certain studies indicate that the average consumption of water is nearly 75 l per day during summers and 50-60 l per day in the winters.

The region has several traditional water practices that are being used by the locals passed down from generations and culminating from the geophysical characteristics of the region. Local residents largely are sparse with water usage especially in the Ladakh region due to limited availability of water. With changing lifestyles, emerging commercial sectors such as tourism, new water sources and increasing rural urban migration, these practices are slowly fading. The use of dechods or 'dry toilets' is another traditional practice in the region where the human waste is converted into organic compost and used for enriching the soil used in agriculture. The traditional structures include ponds that are the water harvesting structures in which melted glacier water is collected and used once its melts and yuras that are gravity channels dug in the soil wherever required to divert water from the main drainage.

On the energy front, Ladakh has reached the 100% electrification mark in 2018-19 and all of the 113 villages in the Leh district and 128 villages in Kargil district were electrified under Deen Dayal Upadhyay Gram JoytiYojana (DDUGJY), wherein most of the villages are not connected through the existing transmission and distribution network, due to the rough terrain and altitude. Thus, the reliability on decentralized micro power plants (most of them diesel based) largely exists to cater to the energy demand throughout the year in these settlements.

3.1.1 Pertinent Challenges

- One of the major challenges includes high dependence on groundwater for residential purposes. The problem is exaggerated by the lack of any water management tools such as the water meters in the households
- High dependence on fossil fuels for all types of residential purposes- cooking and heating.
- Decentralized waste collection from households and non-segregation of waste at the household levels also enhances the magnitude of the problem.

3.2 Energy

The energy sector will be critical while paving the path to carbon neutral Ladakh. The envisioned sustainable development will require comprehensive changes in how the energy supply is managed in addition to managing the demand sectors including transport, buildings, and agriculture systems where most of the energy is being consumed. Energy supply in Ladakh was historically dominated by fossil based diesel electricity generation at centralized as well as decentralized levels. The hydel based generation now juxtaposes with the diesel in summers while latter continue to dominate in winters.

The net electricity demand of the UT in 2018-19 has been around 138 MU which is split between the two districts, as ~60%in Leh and rest in Kargil. The energy consumption patterns have shown a steady growth in trends over the past 5 years, with the increase in peak load by around 25% annually (CAGR) in both the districts. This implies that the load connectivity has been increasing at a higher rate.

To cater to the growing demand, Ladakh has installed capacity around 143 MW that includes Hydel plants, Diesel gen-sets, Solar Hydroelectric and few solar PV micro grids. The energy demand of the UT largely differs as per weather conditions, with 15 to 25 MW in summers which spikes up to 25 to 40 MW in harsh winters. This makes the UT a power surplus region in summers while power deficit in winters, as the availability of hydel plants reduces to only 25% in winters.

There is no denying of the fact that Ladakh is enriched with renewable sources which is yet to be tapped, with solar energy potential as high as 35 GW and geothermal and wind energy sources for which assessments are undertaken. National Institute of Wind Energy (NIWE) has assessed the wind energy potential of around 100 GW at hub height of 120 meters, but due to complex terrain and transportation challenges NIWE recommended sub-MW turbines at 80 meters, which has the potential to harness 5 GW of energy. In addition small hydro project has the potential of 395 MW out of which nearly 100 GW is already installed, while some assessments also shows the 200MW of geothermal potential which is at the exploratory level. The development in these directions can make Ladakh a Renewable power house of India, and will contribute to nation's growth.

The UT is domestic heavy region with residential sector consuming around 45% of the overall consumption followed by commercial, army and industrial. Of the two districts, Leh has domestic and commercial consumption around 30% each, due to the predominant tourism activities. Whereas Kargil correspond to the residential consumption around 67%, followed by army.

The energy demand and supply pattern of UT of Ladakh widely varies across different seasons, different sectors, and locations per se. This disparity makes it challenging for the energy planning of the region.

3.2.1 Pertinent Challenges

The major challenges in the sector pertain to limited grid, heavy dependence on diesel for power generation and transmission related challenges.

3.2.1.1 Access to Grid Electricity

While all of the Ladakh has been electrified, access to grid electricity is yet to reach in most of the remote areas. The power is supplied in the remote locations majorly through large decentralized diesel gensets which are maintained by the Power Development Department (PDD).

Grid Extension Challenges

Expanding grid transmission network has been hindered by rough terrain at high altitudes, high infrastructure costs, scattered population (especially in rural areas), and high operational costs that poses challenges for the utility (currently no DISCOM in UT, maintained by the PDD) and consumers ability to pay. The extension projects in the formidable regions are neither technologically feasible nor economically viable.

Curtailed Electricity in Off-grid region

Diesel gen-sets in non-grid connected areas had been supplying only 8 hours of electricity per day. This leads to more reliance on non-electric energy usage, polluting as well.

Table 1: Electricity connectivity in Rural Areas (Source: PDD)

	Leh	Kargil	Total	
Total Villages	113	128	241	
Grid Connected	62	89	151	63%
DG set	38	28	66	27%
Solar	13	11	24	10%

Source: Power Development Department, Ladakh

3.2.1.2 Domination by Diesel Gensets

The dependency of Ladakh for electricity supply had always been on the conventional diesel gen-sets, which ultimately lead to the environmental impacts leading to enormous GHG emissions and local pollution as well. The issue of black carbon emissions is also predominant due to inefficient combustion of diesel at higher altitudes with lesser oxygen availability in air.

In winters there is a peak demand supply gap of 24 MW which is met by DG sets. Further, 112 habitations with about 5300 households comprising of about 10% of total consumers are not connected with grid and are supplied with power either through DG sets or standalone solar systems. The rooftop solar PV is also not popular in the region, due to high upfront costs with no subsidy scheme and highly subsidized grid electricity.

Non- Reliable supply from solar micro-grids

Currently, out of 37% off-grid villages in the region, 10% are fed electricity with solar micro-grids which faces the intermittency issues and problems pertaining to operations and maintenance of these solar based decentralized systems. This has led to shifting of few villages from solar to diesel gen-sets which raises concerns for a smooth transition to decentralized renewable development.

3.2.1.3 Transmission Challenges

The twin issue of Ladakh being energy surplus in summers and energy deficit in winters has been resolved in 2019, with the connectivity of UT with the northern power grid via the 220kV Srinagar- Alusteng- Drass- Kargil- Leh transmission network. The supply network has also been improved with the construction of new modern Gas insulated Sub-stations of 220/66 kV at Drass, Kargil, Khaltsi and Leh to help ensure 24X7 quality power in all climatic conditions.

Inefficient Transmission

The average transmission and distribution (T&D) losses are approximately 25% in the region, one of the lowest in the country. This means that almost 25% of the electricity generated at power plants is lost while reaching the consumption point. The overall losses including commercial losses stands around 45% which depicts the low billing and collection efficiency of the utility, which can hamper the sustenance of the electricity sector.

Inadequate Transmission Lines for evacuation

Recent past developments has pushed the UT for the massive solar energy generation in coming future. The existing transmission network can only facilitate the 300MW of power evacuation. The incapability of power evacuation has been the barrier in large scale projects development.

3.2.1.4 Fossil based non-electricity energy requirements

While there is impressive growth in electrification of the region, but when it comes to the heating requirements, electricity has been discouraging source both due to incapable system capacity to take high loads of electric heaters and quality of heat not being at par to the desired levels. This in-turn is fulfilled by usage of fossil fuels mainly kerosene, biomass and dung which is detrimental to not only the environment but also human health due to possible indoor air pollution.

3.3 Transport

Growing tourist footfalls, increased urbanization, absence of adequate public transport systems have driven up demand for personalized vehicles in Ladakh. As per the estimates of regional transport office, the total registered vehicles in Ladakh stood at 24092 for 2018. Leh had a share of more than 85% in the total vehicular fleet. The personalized vehicles in Ladakh had a share of nearly 60% indicating significant reliance on personalized mode of transport. It was in five years that the share increased from almost 50% and is expected to reach two thirds in another five to seven years.

The region has received massive public investments in infrastructure, especially in road construction to improve access from the Indian lowlands across the Himalayan range. Improving and extending road infrastructure has also contributed to increased motorization in the region. Promotion of rural connectivity and mainland connectivity at high altitudes has found substantial attention in recent years. Defying odd weather and difficult terrains, agencies like Public Works department (PWD) and Boarder Roads Organization (BRO) through their Himankand Vijiyak projects have been constructed and currently maintain most of the road networks in region. PWD and BRO respectively maintain a total length network of 296 Kms and 2195 kms in Leh, while the roads maintained in Kargil by these organizations were reported to be 1426 kms and 450 kms in 2018-19.

Due to Ladakh's strategic location and the recent border stand-off with China, UT of Ladakh has witnessed growing deployment of army vehicles. Although accurate numbers are not available, however, based on discussion with stakeholders, the estimated number of light and heavy duty vehicles has been reported between 5000 to 7000.

3.3.1 Pertinent challenges

The transport sector in the region contributes massively to the overall GHG emissions owing to the growing tourism, high private vehicle movement and army fleet movement. In addition, infrastructural development for public transport has not been adequate. The present transport challenges are infrastructure and environment related.

3.3.1.1 Infrastructural challenges

Absence of adequate public transport

The public transport facility in Ladakh is currently limited and confined mostly in Leh town. This has led to recent proliferation of personalized vehicles in the region. Currently it has only one major bus depot and the local public transportation (within 30 kms) requirement is met by buses that are privately operated. With the formation of the UT Ladakh last year, the J&K government had directed the State Road Transport Corporation (SRTC) to contribute 100 vehicles to the region. However, concerns have been raised with regard to the conditions of the fleet available. However, Ladakh is uniquely positioned to develop contemporary transport infrastructure which is also environment friendly.

Figure 3: Leh Bus stand

Source: *Photo by Swati Ganeshan (TERI)*

Parking woes

Growing number of registered vehicles over the years (including presence of temporary vehicles during peak seasons arriving from other states) add to traffic woes in the form of frequent traffic congestions, posing greater challenge to public authorities, commercial establishments and local residents. Absence of dedicated parking, particularly near market places and commercial institutions often lead to unregulated traffic management. Moreover, mountainous terrain provides restricted opportunities for dedicated parking spaces. The situation is further complicated by the absence of a well-connected public transportation system.

3.3.1.2 Environmental Challenges

Difficulty in vehicle retirement

Due to extreme weather particularly during winters, many roads in Ladakh remain non-motorable. As a result the use of vehicles is reported mostly during summers. Although the motor vehicle act mandates issuance of certificate of fitness for the commercial vehicles of 10 years, there are concerns that have been raised regarding the mileage that most vehicles have during this period. Most of the vehicles in winter are not used as diesel cars are hard to operate in winter. Compared to other cities and town in the country the average mileage of vehicles in Ladakh is comparatively low. There is a growing call among vehicle owners to take these aspects into consideration while granting certificate of fitness.

Emissions from vehicular movement

Tail pipe emissions and the consequent impact on ambient air quality from internal combustion engine driven vehicle use has a degrading impact on the environment. As per a recent study, detailed examination of the soil along the 300-mile route between Manali and Leh to check for the presence of common exhaust has revealed soil contamination with hydrocarbons along with sulfur, total organic compounds and certain types of heavy metal. These results indicate presence of fair amount of emissions accumulation in the soil.

Most of the vehicles used by civilians are either BS3 or BS4 compliant with a higher share of BS3. Further in higher terrains, the average speed and fuel economy is quite low leading to more tailpipe emissions.

3.4 Commercial

The commercial sectors comprise tourism and all commercial establishments pertaining to shops, office spaces and private buildings.

3.4.1 Tourism

Ladakh is widely known for its wide array of tourism activities. Since the opening of the tourism activities in 1974, there has been an increased growth in the number of international and domestic tourists in the region. Tourism contributes to almost 50% of Ladakh's GDP. Some of the general trends in this sector are highlighted below in Figure 4 and 5: The period between 2007-2017 has witnessed an increase of tourists in Leh by 280%. Overall, there has been a 15% growth in Ladakh (including Kargil) in the last 5 years.

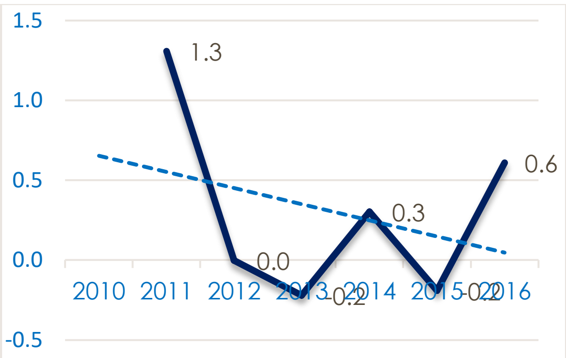


Figure 4: Growth rate of Tourists in Leh

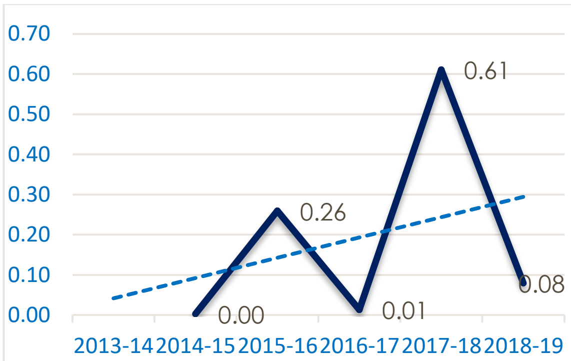


Figure 5: Growth rate of Tourists in Kargil

Source: Disrict Statistical Handbooks for Leh and Kargil

The sector is highly dominated by domestic tourists. The composition of the international tourists varies in the range 12-16% (approx). The peak months in domestic tourism mostly cater to the months May to September every year when the weather is warm. There are various categories of tourist accommodations in the region. As of 2016, the number of hotels (3 star, A+, A, B, C. D), guest houses (Upper, Medium and Economy) and travel agents were 213, 433, 468 respectively. Similarly, in Kargil the total number of hotels, guest houses and restaurants as of 2018 are 34, 82 and 9 respectively. The sector provides employment to youth who are engaged as tour guides, helpers, travel agents and taxi drivers. Rapid growth in the tourism industry has also led to the increase in rural to urban migration in the region which also acts as a stress point. Similarly, lack of adequate infrastructure has impeded the development of tourism sector in Kargil. The entire road stretch from Chutuk, Minjee to Stickchey village has huge potential for tourism development.

3.4.2 Pertinent challenges

The primary challenges emanate from the environmental degradation caused due to anthropogenic activities necessarily resulting from inefficient management, lack of infrastructural facilities and challenges emanating from pervasive behavioral traits of tourists.

3.4.2.1 Management related Challenges

These challenges cater to the energy intensive activities in the various types of accommodations such as hotels, restaurants and guest houses, local transport availed for tourists for sight-seeing purposes and the solid waste generated by tourists. Management inefficiencies cater to water use, energy consumption and generation of solid waste.

Water Consumption

- The tourist accommodations depend heavily on groundwater due to inconsistent piped water supply. The extraction of water depends on the extent of water use for various activities by tourists. Primary survey indicates that the extraction of borewells happens on an ad hoc basis without approval of the relevant authorities. Moreover, there is no use of any water regulating tools such as water meters to measure the daily consumption of water.
- Most of the washrooms in the tourist accommodations have modern day toilet facilities vis-à-vis the traditional dry toilets as is available in Ladakhi households, thereby provisioning for increased use of water in a water-constrained terrain. Anecdotal reference suggests that during the summer, the Ladakhi dry toilet is mostly used by the family owning the guest house or their staff. A tourist survey conducted by Gondhalekar (2014)[1] reveals that a mere 1 percent of the interviewed tourists admitted to having used a dry toilet during their stay in Leh town.
- Moreover, there is no infrastructure to treat wastewater generated across the various tourist accommodations.

Energy Consumption

The energy intensive activities in Ladakh cater to the tourist accommodations and transport sectors. In the tourist accommodations energy intensive activities include heating and

[1] Keilmann-Gondhalekar, Daphne &Akhtar, A. (2014). Towards an eco-tourism approach: Tourism impacts on water resources in Leh town. Ladakh Studies. 30.

lighting through various appliances such as water heating using centralised geysers, common light bulbs and LEDs, refrigerator and air conditioners which are all based on electricity from non-renewable sources. In order to provide steady electric supply to tourists, several hotels rely on power back-ups through generators which are primarily based on diesel. Barring a few high cost hotels, most tourist destinations do not have any provision of solar electricity generation through installation of solar panels. For that matter, there is a high dependence on fossil fuels for water pumping. Transport availed by tourists is also energy intensive as they mostly depend on private modes of transport such as taxi, cab and bikes for sight-seeing.

Solid Waste Generation

The process of waste collection from hotels is decentralised and most of the waste collected is dumped in the Bomgarh region which is within the periphery of the residential area. This results in several health hazards for the residents in the region. Secondary literature indicates that the quantum of solid waste generated in Ladakh amounts to 1.15 mt in summer and 0.16 mt in winters (Wani et al., 2020) [2]

3.4.2.2 Transport related Emissions

The unprecedented growth in tourist footfalls in recent years has substantially contributed to increased registration of commercial taxis and campers. Almost 100% of the visitors travel by air or road, with only a very limited number trekking in from Himachal Pradesh or Kargil district to Leh. Out of total registered commercial vehicles of 8952 reported in Leh in 2019, cabs and related vehicles accounted for 75% of the total commercial fleet. Future rail connectivity and expansion of the current terminal will attract more tourists that will see more number of the vehicles on road.

Situations are complicated especially during peak seasons when the total tourist population exceeds the local population as has been observed in the past few years leading to a sudden spike in vehicles and increased emissions of particulate matter (PM), hydrocarbons and oxides of nitrogen among others. Hydrocarbon arises due to incomplete fuel combustion, leakage past the exhaust valves, valve overlaps etc. Emission of oxides of nitrogen leads to photochemical smog. Inadequate availability of concerned staff for vehicle emission monitoring leads to frequent unnoticed violations particularly during these seasons. Extreme cold weather is also not very conducive to supporting engine efficiency of the vehicles.

[2] Wani, Muzafar& Shah, Shamim&Kamraju, M. &Akhter Ali, Mohd & Dar, Sajad. (2020). Hospitality Industry in Ladakh: Assessing the Volume of Solid Waste Generation of Operation Restaurants of Leh Town through Spatiotemporal Method. 08. 144-151.

3.4.2.3 Behavioral Challenges

There are certain behavioral traits of tourists which gives rise to several challenges in the region. Secondary sources of data suggest that the daily average consumption of water by a domestic tourist is 100 litres in summer and 60 litres in winter. In contrast to this, the estimates are significantly lower for that of an international tourist (LEDeG, 2019)[3]. Moreover, an ordinary tourist usually prefers modern day toilet vis-à-vis a dry toilet (as is common for a Ladakhi household).

3.5 Agriculture and Forestry

About 70% of the population directly or indirectly depends on agriculture for livelihood. However, only 0.36% of the total geographical area of Ladakh is under cultivation (Table 2). Similarly, the area under forest cover is 4.2% with 3.1 %, 26.9% and 70.3% of forest area as very dense forest, moderately dense forest and open forest, respectively and grassland/grazing land being the principal vegetation type.

Table 2: Land-use – Ladakh Region (sq. km)

Districts	Forests	Cultivable land	Other land uses
Kargil	59.70	111.80 (100.3)	13864.50
Leh	2429.60	105.40 (99.6)	42575.00
Total	2489.30	217.20 (199.9)	56439.50

Note: Figures in parentheses indicate net sown area

Agriculture production in Ladakh is entirely based on irrigation by means of gravity and river canals and concentrated towards the cultivation of barley and wheat. Peas, mustard, potatoes, carrots, turnip, radish, green leafy vegetables, and alfalfa are also regularly cultivated on terraced fields accompanied by apple and apricot trees, with increasing demand for vegetables and other crops near urban centres, particularly from hotels and armed forces. Furthermore, Salix (willow) and Populus (poplar) species are cultivated in irrigated areas, to meet the local demand for fuel and timber wood. Animal Husbandry is an important allied sector of agriculture and plays a pivotal role in the rural economy of the district with majority of the population being agro-pastoralists.

Due to the short growing season which last for about 4-5 months, mono-cropping is practiced with few exceptions of villages located in the lower valley. Dual cropping of leguminous crops such as lentil, field pea and French bean is undertaken in the lower valley with an altitude of less than 3000 metres. The share of wheat in total cropped area started decreasing along with area under barley after 1999-2000. This decline was because of introduction of Public Distribution System in the region during post-1970s phase. Ladakh

[3] Liveable Leh, Report prepared by LEDeG

has become largely dependent on rice and wheat imported from outside areas in recent years. Nearly 2.19% of the total cultivated area was under fruits and vegetables in 1970 but it has increased by more than 50% in 2012-13 (Table 3).

Table 3: Area under principal crops in Ladakh, 1999-2013 (Area in terms of percentage to total cropped area)

Year	Wheat	Barley (Grim)	Other food grains[1]	Fruits and Vegetables	Oilseeds	Fodder crop
1999-00	22.00	0.80	53.40	3.30	0.10	20.30
2004-05	21.40	0.40	47.90	2.80	0.30	27.30
2009-10	20.90	0.20	46.90	3.90	0.40	27.60
2012-13	13.20	0.02	50.50	4.30	0.50	31.50

Source: (Dolker, 2018)

Majority of the soils in Leh and Kargil districts are sandy to sandy loam in texture and medium to medium high in organic matter with poor water holding capacity. Nutrients are below the critical level except potassium which is relatively high. Farmers in both Leh and Kargil have been using a combination of animal dung and human excreta as manure to enrich the soil along with partially decomposed farm yard manure (Pelliciardi, 2011). There is a reduction in the usage of overall consumption of chemical fertilisers in Ladakh over the period 2011/12-2016/17 with considerable variation in chemical fertilizer use across blocks; from 9.6 thousand quintals to 8.5 thousand quintals in the case of nitrogenous fertilizers, and from 5.9 quintals to 4.0 quintals in the case of phosphatic fertilizers (LAHDC, 2016). Farmers have also started developing vermi compost due to the lack of chemical fertilisers during the peak growing season (Aziz, et al., 2017).

Two types of irrigation systems are predominant: snow- and glacier-fed (rotational system for water distribution) in the tributary valleys and Indus based irrigation network in the main valley. In order to conserve the winter water and minimise water shortage during the onset of the summer months, artificial glaciers are being erected across villages to facilitate the irrigation of crops and trees. Irrigation is traditionally managed and maintained through a proper local institutional set up which is also responsible for the maintenance of infrastructure such as canals/kuhls and distribution of irrigated water among the village folk.

3.5.1 Pertinent challenges

Agriculture in Ladakh is challenged by low soil fertility, poor infrastructure, small landholding size and mountainous terrain, all of which make the activity labour intensive. Although agriculture with harvesting glacier has come-up as a small-scale farming system, delayed snowmelt and winters with less snow lead to minimal water availability during the sowing period in April/May (Labbal, 2000). A study indicated that villagers faced insufficient water for irrigation on account of less snowfall during winters (Yangchan, et al. 2019). Moreover, there is limited awareness among farmers regarding interventions including integrated soil health, nutrient management, and agronomic practices to achieve good quality crop and livestock produce. Given the potential of organic farming, the regions availability of required quantity of organic manures for practicing organic farming is a limitation. Further availability of human waste for use as organic manure has become an issue due to shift from traditional dry toilet to Western toilet. Deficiency of fodder is also a major constraint for livestock production systems in cold arid regions of Ladakh. Shortage of alfalfa and receding area of cereal crops are the main bottleneck for livestock production. Further, the effect of grazing on the carbon balance is poorly understood, but given the high livestock numbers, it can play a significant role in the carbon balance. The greatest threat to forests is the land-use change and deforestation. It is not clear how much of each land category is suitable for afforestation for carbon sink creation.

3.6 Urban Management

The urban management space constitutes of water management, construction and solid waste management.

3.6.1 Water Management

Ladakh lies in the area of Indus Valley basin where the Indus flows over a large floodplain at an altitude between 3300 m and 3100 m. The Upper Indus Basin at Leh is bounded by the Ladakh Range to the north and the Stok Range to the south. The steep slopes are dissected by numerous tributary valleys, some of them without perennial runoff, terminating in large alluvial fans, where almost all scattered settlements are located[4]. Two main rivers flowing in this area are Nobra and Shyok Rivers. Nubra is a perennial river which originates from Siachan Glacier and flows from North West to South East direction. Shyok River is also a perennial river which originates from South Rimo Glacier and Central Rimo Glacier[5].The Kargil district lies in the lower Suru basin. Two rivers that meet in Kargil are Drass and Wakha.[6]

Because of the rain shadow effect of the Himalayan Range, mean annual precipitation in Leh (3506 m) totals less than 100 mm, and there is high interannual variability. There is also high

[4] Nusser, Marcus, Schdmidt, Susanne, Dame, Juliane (2020), "Irrigation and Development in the Upper Indus Basin", Mountain Research and Development, 32(1): 51-61

[5] CGWB (Central Ground Water Board), Ground Water Information Brochure of Leh District, CGWB: Central Ground Water Board

[6] Town Planning Organisation, Kashmir (2018), Master Plan of Kargil, Draft Master Plan Report, Feedback Infra Pvt Ltd & BE Consultants

variability annually ranging from 142.5 mm to 18.2 mm[7]. In Kargil, the average annual precipitation is usually higher than Leh, upto 150 mm3.

3.6.1.1 Sources of Water

There are two major sources of water- surface water and groundwater. Among the surface water sources, natural springs are prominent sources and surface streams which used to be traditional sources of water until 15-20 years ago. But as these streams are now being obstructed by constructions or polluted, major dependency on surface water has switched to groundwater sources4. However in Kargil, the major dependency is still on surface water sources and springs for meeting water supply requirements.

The groundwater sources of water include both public and private tube wells. In total there exist 12 public tube wells, out of which 11 are located in Leh and 1 in Kargil. These public tube wells are owned and operated by the PHE department. The water once extracted from these tube wells is then pumped to Service Reservoirs (SR) and supplied through gravity water system to various household connections or Public Stand Posts (PSPs). However, during winters the dependence on piped water completely drops due to freezing and switched to water tankers. The private bore wells are another important source of water especially in Leh town and the dependence on them have increased tremendously in the past decade. Currently there is no record of the number of private bore wells in the region, but according to the BORDA estimates, there exist around 1,200-1,700 bore wells to supplement PHE’s supplies. However, in Kargil dependence on groundwater is relatively low and people mainly depend on surface water and natural springs for meeting their requirements. The groundwater samples of collected in the region for conducting a study have indicated the presence of arsenic which may have adverse health impact if consumed for a longer period[8].

3.6.1.2 Water Demand

The demand for water in Ladakh considerably varies in the summer and winter seasons and also across the different categories of users. As indicated in figure 6, the locals and migrants considerably use less water as compared to tourists and this usage further reduces during winters.

[7] BORDA (Bremen Overseas Research and Development Association) (2019), Water in Liveable Leh! Report on Water Supply and Usagen the highest town of India, BORDA: Bremen Overseas Research and Development Association, South Asia

[8] Lone, A. Suhail, Jeelani, G., Mukherjee, Abhijit, Coomar, Poulomee (2020), “Geogenic groundwater arsenic in high altitude bedrock aquifers of upper Indus river basin (UIRB), Ladakh”, Applied Geochemistry 113 (2020) 104497

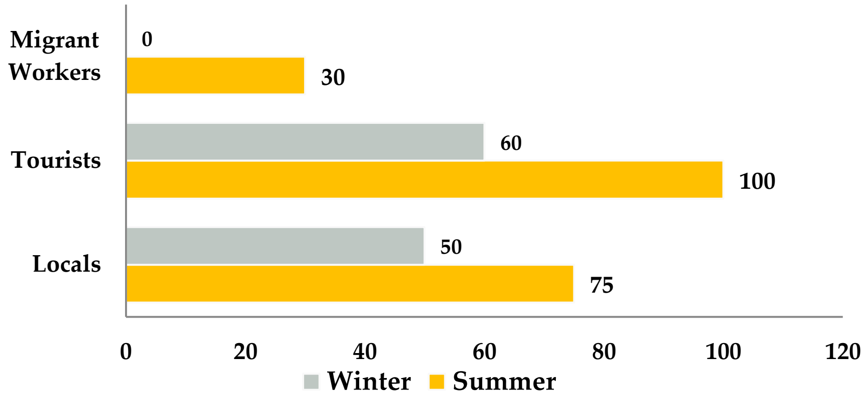


Figure 6: Comparison of Water Usage across Users and Seasons (in litres)

Source: BORDA, 2019

As is illustrated in figure 6, during summers, locals use approximately 75 Litres of water per day, tourists use 100 L/day and migrants get only 25-35 L/day. In winters, the consumption decreases to 50L and 60L among the locals and tourists per day respectively. There is no consumption of water during winters among the migrants as they move out of Ladakh. With rising tourists in the UT, the demand for water is expected to rise in the future and is likely to pose higher pressure on the existing water resources.

3.6.2 Household Connections and Metering

In Leh, till 2018, around 66% of the urban households have been connected through pipe line connections, but the rural households are supplied water through tankers (BORDA 2019). In Kargil as well, the town is supplied water by the PHE but the rural areas use surface water through Wakhanallah and River Suru (Master Plan of Kargil). An annual water tariff of Rs. 820/year/HH[9] is charged by the PHE which helps recover only 5.8% of the total expenses of operating the water system.

3.6.2.1 Sewerage System and Wastewater

Currently there does not exists a proper sewage network in the UT and wastewater mostly flows into septic tanks and soaks pits and finally seeps through the ground. This is leading to groundwater pollution in many areas. However, a sewerage system is under construction and a 3MLD[10] sewage treatment plant is being constructed and is expected to connect around 40% of the town area (BORDA 2019). Leh also has a Faecal STP with a treatment capacity of 12,000 litres per day and since its inception in 2018, around 5 million litres of faecal sludge has been safely collected and treated.

[9] Data from the PHE Department, UT of Ladakh
[10] Million Liters per Day

However in Kargil, there exists no such organized system sewage system and sewage generated is either directly discharged into the nearby drains without any treatment or after partial treatment through septic tanks.

3.6.3 Pertinent Challenges

Primary survey in the region reveals that the UT is not facing any water crisis but a gross water management crisis. However, although Kargil has a significant number of water sources, the district of Leh has minimal sources of water due to its geography and climatic conditions. The region faces an erratic water supply system, increasing water demand due to rising tourism and inhabitation and groundwater pollution due to the absence of a proper sewage system. The water management challenges pertain to infrastructural, technological, financial, regulatory and human resource issues.

3.6.4 Inefficient Water Supply System

The various water management challenges include inefficiencies and underutilization of resources. 25-30% of water losses are due to inadequacies in the water network. The Service Reservoirs (SRs) do not have any metering system to monitor the amount of water received and discharged from each SR every day and there are no systems in place to detect any leakages in the water distribution pipelines[11]. Further the dependence on diesel based pumps is more in the PHE owned tube wells as compared to electric tubewells in Leh, however Kargil has complete dependence on diesel based pumps which is a major source of emission. The piped water system is still under construction and around 96% of the total households are without a functional tap water connection[12]. Currently, the government charges an annual fixed tariff from the connected households and commercial units but the total billing from the registered connections is far less than the cost of operating the system.

3.6.5 Lack of Sewage System and Sewage Treatment Facility

Currently both the districts in the UT, Leh and Kargil do not have a proper sewerage system setup as well as a sewage treatment plant which leads to increasing groundwater pollution. The wastewater mostly flows into septic tanks and soak pits and into the ground. A 3MLD sewage treatment facility is under construction in Leh but it is expected to connect only 40% of the town area, however Kargil does not have any proposed sewage treatment facility yet.

3.6.6 Increasing Groundwater Extraction

The rising demand for water and glaring demand and supply gaps have led to increased extraction of groundwater in several parts of the UT. The installation of private bore wells has increased multifold in the last few years in Leh and there is no proper permit or fee structure in place to monitor. Currently no data is available regarding the number of private

[11] As per the consultation from the PHE Department, UT of Ladakh.
[12] Vision 2050 for UT of Ladakhhttps://cdnbbsr.s3waas.gov.in/s395192c98732387165bf8e396c0f2dad2/uploads/2020/09/2020092627.pdf

bore wells in the UT. Currently, this issue only persists in the Leh town and groundwater extraction related activities aren't being practiced in Kargil significantly.

3.6.7 Lack of awareness and fading traditional practices

Ladakh is geographically a 'cold desert' despite having many sources of water like rivers, springs and canals but the tourists are not aware of the regions' climatic and geographical characteristics. This lack of awareness and behavioural rigidness among the tourists has become one of the major causes of water crisis in the region. Further the tourists are not aware of the traditional practices like the 'dry toilets' which is practiced in every Ladakhi household. The hotels, guest houses and even homestays prefer installing modern toilets for tourists which ultimately leads to increased water consumption.

Strong traditional practices such as the *Churpon* system (Churpon meaning 'water lords') that are still practiced widely in Ladakh region need to be further promoted to ensure their continuity. Churpons are elected water officials who ensure equitable water distribution for farmers in Ladakh. The officials are elected by the village/ community and have been critical for water management in the region.

3.7 Construction

Ladakh as a region has gone through tremendous transformation in the past few decades and specifically the Leh town area. The region has witnessed higher rates of urbanization since the 1980s, rural-urban migration and economic changes like the shift from agricultural sector to the service sector. The total population of the UT has increased from 2,74,289 to 2,36,539 between 2001 and 2011, however the overall urbanisation rate of the UT has remained constant since 2001 but the wide variability can be seen at the district level. The population between Leh and Kargil is almost equally divided but the urbanization rates of both the districts vary largely. As reflected in Figure 7, the urbanization rate of Leh is almost double that of Kargil.

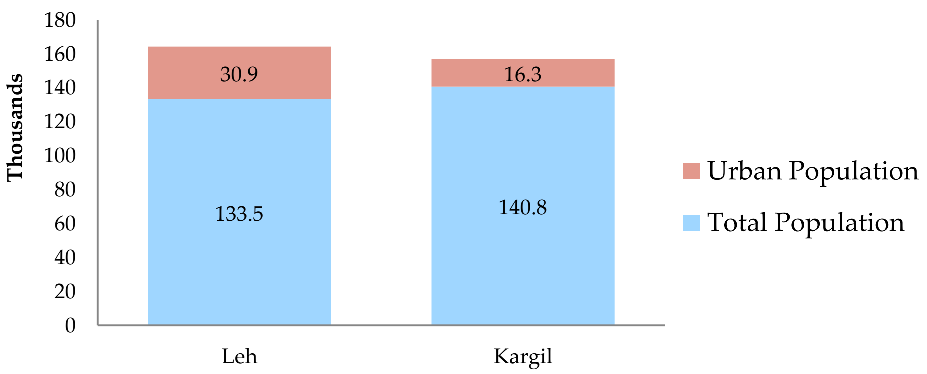


Figure 7: Total Population and Urban Population in Leh and Kargil in 2011

Source: District Statistics Handbook, Leh (2016-17); District Statistics Handbook, Kargil (2018-19)

Figure 7 shows the comparison of the total and urban population in both the districts and indicates that the urbanization rate in Kargil was 12% in 2011; whereas it was 23% in Leh. In the last two decades, the population of Leh town has more than tripled as the town faces an immense amount of 'floating' population every year.

This rapid demographic growth has led to increased construction activities and infrastructure development between the time period 1969 and 2017 the built-up area has more than quintupled from 36 ha to 196 ha. A total of 9260 new buildings have been constructed between 1969 and 2003, 4780 between 2003 and 2011, and 4620 between 2011 and 2017 (Dame et al. 2019). This urban expansion and construction of new buildings have been both in barren regions of the town and the agricultural land areas. By 2003, new settlements developed in the barren lands of the town resulted in a drastic increase of buildings to about 11,800. Similarly, the expansion into arable land has been large. Between 1969 and 2017 the percentage of agricultural land loss increased from 1% in 1969 to 5% in 2003 and by 2017, it had risen to 8% (ibid.). Many of these constructions on the arable land are buildings catering to the tourism sector, like hotels and restaurants.

A traditional house in Leh
(Photo by Dinodia)

3.7.1 Types of Structures

Both the districts of Ladakh, Leh and Kargil have a higher share of residential buildings than commercial or industrial. Leh had 21,424 total households[13], 1,314 hotels and restaurants, 2,811 commercial establishments and 5,497 shops in 2015-16[14]. However, Kargil had a total of 18,012 households[15], 513 hotels and restaurants, 2,907 shops and 461 commercial establishments in 2015-16[16]. Even among the residential buildings, maximum numbers of dwellings have more than three rooms (34%), followed by 21% of two rooms. Similar trend exists in Kargil where more than 30% of the household dwellings have more than three rooms, followed by two room dwellings. Also both the districts have a majority of A-class hotels which are the high 3.7.2 end hotels and their energy consumption patterns are usually extensive.

3.7.2 Type of Building Material used

[13] Government of Jammu and Kashmir (2017), Statistical Handbook Leh, 2016-17, Government of J&K and Ladakh Autonomous Hill Development Council

[14] Directorate of Census Operations, Jammu & Kashmir, District Census Handbook, Leh (Ladakh): Village and Town Wise Primary Census Abstract (PCA)

[15] Government of Jammu and Kashmir (2017), Statistical Handbook Kargil, 2018-19, Government of J&K and Ladakh Autonomous Hill Development Council

[16] Directorate of Census Operations, Jammu & Kashmir, District Census Handbook, Kargil: Village and Town Wise Primary Census Abstract (PCA)

A modern building in Leh
(Photo by Mani Juneja, TERI)

In Ladakh, earth and stone are the most common building materials used. Both walls and roofs are built in earth. All the older houses and most of the new constructions use hand moulded adobe in walls and rammed earth on timber under structure for the flat roofs[17]. Due to the high need for thermal comfort, the type of material used in the building is very important and the concrete blocks might not be either suitable to the weather conditions or energy efficient in this case. Therefore the use of mud as a basic construction material is cost effective, sustainable and fulfills the thermal requirements. The buildings constructed in the region are generally south facing to enable maximum capture of sunlight, thereby decreasing reliance on diesel and kerosene for both lighting and heating purposes. Table 4 shows the comparison of different types of bricks and their ecological specifications.

Table 4: Ecological comparison of building materials

Product and thickness	No. of units (per m2)	Energy consumption (NU per m2)	CO2 emission (Kg per m2)
Stabilized Compressed Earth Block (SCEB)- 24 cm	40	110	16
Wire Cut Bricks-22 cm	87	539	39
Country Fired Bricks-22 cm	112	1657	126
Concrete Bricks-20 cm	20	235	26

3.7.3 Pertinent Challenges

3.7.3.1 Unplanned expansion of construction activities

Both the districts of the UT, Leh and Kargil are witnessing unplanned expansion of buildings especially residential and commercial (like hotels and guest houses) on arable land and even on forest land in Kargil. Such activities are not only resulting in depletion of the hills and but also distorting the existing valuable eco-system. Kargil has seen a reduction in area covered under agricultural, plantation, horticultural and forest in the past. Quarrying activities for construction material without any regulation in the region is also distorting the local habitation and the ecosystem. Cutting of the fragile hills for the expansion of housing areas is also leading to problems of loosening of topsoil which leads to landslides.

[17] Niazi, Zeenat (1997), "In Search of Technological Alternatives for Construction in Leh", Volume 7 No. 10

3.7.3.2 Higher dependence on fossil fuels

The energy requirements are enormous in the region especially for heating purposes because of harsh cold weather. About two-thirds of the power supply in the summer comes from diesel generator (DG) sets. In 2019, the power development department of Ladakh used 2.1 million litres of diesel and petrol and the transport department used around 33.7 million litres[18]. In the winters specially, the dependence for electricity is higher on DG sets as the capacity of other sources of power like hydel drastically reduces. Also it has been estimated that currently around 8000 litres of diesel are required to generate sufficient power for a day's consumption in Ladakh[19]. Thus the rising pollution levels in the region are a result of high dependence on these fuels which are required to be replaced by cleaner fuels.

Fossil fuels are extensively used for cooking purposes. According to the Census 2011, more than 22% households used firewood for cooking purposes in Leh, however in Kargil the dependence on firewood is much higher (around 70% of households). The energy requirement of the army is also high which is mostly fulfilled using fossil fuels such as diesel and kerosene.

3.7.3.3 Energy intensive structures

Because of the rising residential as well as commercial establishments in the UT, the dependence on fossil fuels as well as high energy needs are causing increase in the emissions. Both the type of material used and the structure of the building

3.8 Solid Waste

Leh is the central point of tourism in the UT of Ladakh. However, the tourism sector is a major contributor to the generation of solid waste in the region. Although the municipality does not keep any record of the total waste generated in the city, certain research work has been conducted to estimate the volume of waste generation. According to Wani (2020), restaurants in the town generate about 1.15 metric tonnes per day in summer season and 0.16 metric tonnes is generated in the winters. Some of the primary challenges observed in this sector are as follows:

- On an average, tourist accommodation of Leh town generates about 5.11 metric tonnes of waste/day during the peak tourist season from April to September, with a per capita waste generation of 1.87 kgs/day/room. This is considerably highly as It is

[18] Data from Power Development Department and Transport Department, UT of Ladakh
[19] Santra, Priyabrata (2015), Scope of Solar Energy in Cold Arid Region of India at LehLadakh, Annals of Arid Zone 54(3&4): 109-117, 2015

reported that if small budget full-service tourist accommodations generate waste between 1.2-1.6 kgs per room/day, it is considered as a satisfactory limit (WWF-UK and IBLF2005; Ball and Taleb, 2011)[20].

- In terms of waste collection, door to door garbage is picked up from households and commercial establishments and no effort is made to segregate the waste at source for recovery and recycling purposes.

- Primary evidence suggests that all the waste generated in the region is dumped at the Bombgarh region which is also a residential area and thereby residents are exposed to various health hazards.

- There is no effort undertaken to recover necessary materials (metals, glass, ceramics, plastics) from various types of waste (construction and demolition, municipal solid waste, due to lack of relevant infrastructure which severely undermines the potential to develop Ladakh into a resource efficient economy.

3.9 Defense

One of the reasons for increased growth rate of population in recent years in Ladakh has been increased deployment of army troops in the area due to its strategic location. The composition of the army is 40,000-50,000 (approx) which is about 15 % of the total population of the region. As a result, there is additional carbon and water footprint in the region. There is huge dependence on diesel generators for power. In terms of transport, ground and air transport of defense personnel and materials is further adding pressure to the existing environment and infrastructure over and above that caused by civilian transport. Possible requirement of the additional defense personnel in the future might lead to more movement of army vehicles in the near term. Keeping aside the fuel consumption in defense sector, nearly 35,000 kl of oil has been consumed in 2019, as provided by the RTO.

[20] WWF-UK and IBLF. (2005)Why environmental benchmarking will help your hotel. A guide produced by the International Business Leaders Forum's travel and tourism program and WWF-UK .cited in www.wgbis.ces.iisc.ernet.in/.../sustainable_waste_management system Ball, S. and TalebAbou M. (2011) Benchmarking Waste Disposal in the Egyptian Hotel Industry Tourism and Hospitality Research 11 (1): 1–18

Chapter 4: Modelling sector Specific region's carbon emissions and mitigation potential

The aim of this chapter is to explain the demand analysis which was done using Low Emissions Analysis Platform (LEAP) tool, followed by defining the overall scenarios and assumptions under each sector. These assumptions were then used to estimate the energy demand and emissions both sector wise and fuel wise

4.1 Demand Analysis using LEAP

The Low Emissions Analysis Platform (LEAP) tool has been used here for modelling the GHG emissions of the region. The LEAP software is utilized by a number of countries for integrated resource planning and GHG mitigation assessments and developing low emission development scenarios for long-term assessments. LEAP follows an end-use, demand-driven approach, which means that the analysis starts from the end-use of energy. The demand program divides the society in a hierarchical tree structure of four levels: sectors, sub-sectors, end-uses and devices. Thus, the different scenarios can be developed by changing the different parameters for future.

LEAP is useful in projecting energy supply and demand situations in order to provide a glimpse of future patterns, identifying potential problems, and assessing the likely impacts of energy policies. LEAP can assist in examining a wide variety of projects, programmes, technologies, and other energy initiatives, and arriving at strategies that best address environmental and energy problems. The main advantages of LEAP are its flexibility and ease-of-use, which allow decision-makers to move rapidly from policy ideas to policy analysis, without having to resort to more complex models.

Figure 8 explains the various inputs and outputs of the LEAP model to estimate the GHG emissions. The various sectors are first defined that are residential, urban management, commercial, industrial, defence and transport in this study. The identification of the sectors is followed by the identification of the sub-sectors under each sector. The residential is divided into rural and urban, urban management has water and street lighting, similarly commercial sector has been sub-divided into hotels, borewells, offices and other buildings and the transport sectors is divided by the type of vehicle. Post the identification of the sub-sectors, the end-usage and fuels are identified. Figure 8 shows the demand tree for the current energy consumption and usage in the region, based on which the GHG emissions have been estimated.

4.2 Defining Scenarios

The study estimates the emissions based on the demand and supply analysis of the region that are built on various assumptions. Any variations in the assumptions help build the various energy scenarios based on which future projections are being made. Thus, energy scenarios outline the future energy perspectives and are based on the various assumptions on technologies, fuel types, or even combination of fuels and technologies. These energy scenarios consider the major environmental impact factors that can lead to any changes in the demand and supply patterns.

For estimating the GHG emissions of Ladakh, the following energy scenarios have been built according to which the future demand and supply have been estimated. The two energy scenarios built were:

- Business-As-Usual (BAU)

The **BAU** scenario here incorporates the existing government plans and the associated technological advancements. Few technological changes and advancements have been considered in this scenario that will be associated with the existing national policy level interventions.

- Alternate (ALT)

The **ALT** scenario takes into account all the existing as well as future government plans and policies that will not only ensure cleaner fuels but also energy efficient measures in the supply side. The demand side of both the scenarios takes into account the growth in the demographic variables, increasing urbanization in the region and the changes associated with the policy interventions. Further the detailed policy interventions considered in both the scenarios are explained in the sector-wise sections.

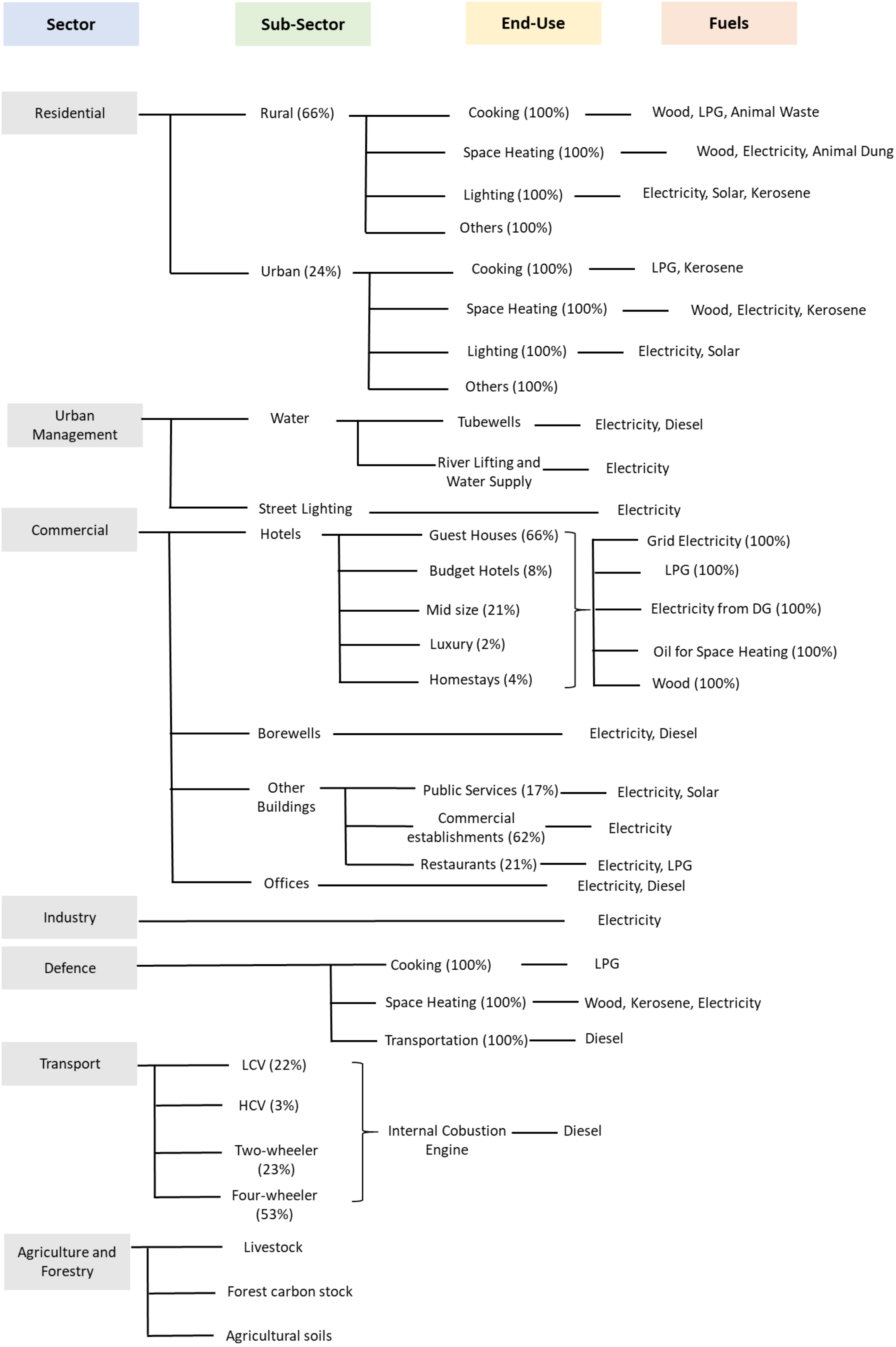


Figure 8: Inputs and outputs of the LEAP model to estimate the GHG emissions

4.3 Data Used and Data Sources

Demography: The data related to the population, number of households, household size, urbanization rate has been sourced from the Census 2011 reports of Leh and Kargil. The future projections of these variables have been done on the basis of the past trends. The number of tourists has also been estimated for the future years based on the past trends as there has been a sudden rise in the number of tourists in the region in the past one decade.

Demand: The demand side of the analysis takes into account all the sectors, their sub-sectors and their different activities. The data regarding the sectors, the technologies used and the fuel usage has been obtained from various government reports including Census, District Statistical Handbooks, Economic Review and reports by multilateral and bilateral organizations, stakeholder consultations, research papers and articles. All the future projections have been done on the basis of past trends observed of the variables.

TED database of Emission factors: The technology and environmental database (TED) of LEAP is used to arrive at the environmental loading or effect of energy usage (i.e. pollutant emission). TED contains emission factors for energy producing technologies, also in the context of the Indian specific usage for some energy intensive activities. However, region specific emission factors are not available, and emerge as the separate domain of research. The IPCC factors for green-house gases where applicable are used for overall estimations. Further any data on technology, demand or supply has been considered based on different stakeholders through multiple consultations.

Base Year: The base year used for the emission inventory assessment is 2018 as the latest available data were available for this year. For some sector, where data is not available for 2018, linear forecasting is done based on the historical trends.

4.4 Energy Demand- Supply for Sectors

The following describes the estimations corresponding to the energy demand and further emissions of sectors across two scenarios discussed. It should be noted that, it was not possible to show the effect of GDP on energy demand, as the demand elasticity with respect to GDP are not known for households, commercial and industrial sectors and hence, annual average growth rate was used based on the historical trends. The sectoral demand and supply of electricity in future has been projected basis the certain assumptions which are discussed in greater details in the following section:

4.4.1 Residential

The CNAP draws on the multiple assumptions for estimating residential sector energy demand to address data gaps pertaining to energy intensity in households and the high share of non-electricity energy usage. The average household size in the urban areas is 5.3 while 7.6 in rural areas. Currently, rural areas of Ladakh constitute 74% of households which at normal pace will decrease to 40% in 2050 assuming the 3% rate of urbanization. While Ladakh has reached the 100% electrification mark in 2018-19, 63% of them are connected through existing transmission and distribution network, 27% through DG sets and 10% through solar micro-grid.

As per current estimates, the per capita electricity consumption in the region is 150 kWh p.a. compared to national average which is nearly 1000kWh. The region is primarily dependent on the fuel-wood, animal wastes and kerosene for heating and cooking applications due to inadequate electricity and LPG supply systems. Although, there has been high consumer registration of LPG for cooking but the usage has not been encouraging.

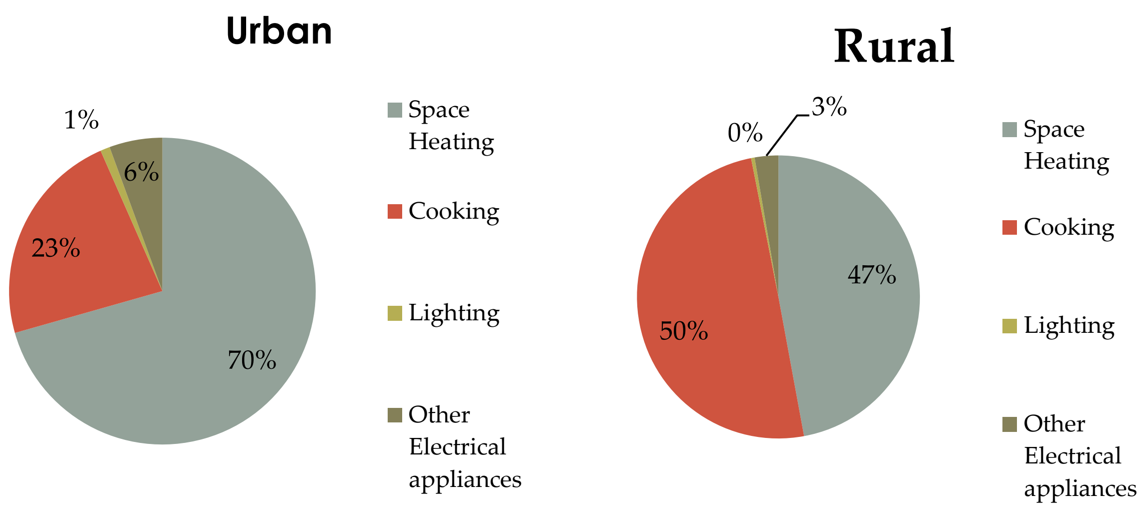


Figure 9: Energy Consumption Pattern in Urban (left) and Rural (right) households

The energy consumption patterns are different in rural and urban households (Figure 9 above) wherein fuel usage patterns also differs for both (Table 5 below). Wherein, the inefficient practices like fuel-wood usage and animal wastes for cooking is predominant in rural areas while urban areas are mostly LPG dependent.

The distribution of different fuel usage in urban and rural households in displayed in Table 5.

Table 5: Distribution of different fuel usage in urban and rural households

Major Activities*	Energy/Fuel Sources	Share in Urban Households	Share in Rural Households
Cooking	LPG	96%	45%*
	Kerosene	1.4%	-
	Wood	2.8%	42%
	Animal Waste	-	13%
Space Heating	Electricity	5%	0%
	Kerosene	30%	2%
	Wood	65%	70%
	Animal Waste	-	28%
Lighting	Electricity	95%	85%
	Solar	5%	14%
	Kerosene	-	1%

*Other appliance like refrigeration, TV, fans, etc. are 100% electricity based

** Does not represent the connection share

The useful energy analysis has been undertaken to estimate the total energy demand based on the efficiency of the appliances used for cooking, space heating, lighting and other electric appliances. This implies that useful energy for cooking might be the same but total energy demand for rural areas will be much higher because LPG cook stoves offer higher efficiency of around 45-50% compared to 8-10% in conventional biomass fired 'Angithi and Chulhas'. The space heating has been the major energy application in the region. The studies reveal that the solar passive houses can reduce the heating requirement by around 70-80% in the region. There lies the huge potential of significantly decreasing the total energy demand for space heating and also the reduction in emissions through electrification of the heating appliances. Due to lack of infrastructure and grid capacity, currently there is very limited usage of electricity for space heating and is also discouraged.

Energy Demand

The total energy demand of residential sector is relatively high from the other sectors, on the account of higher dependency on fuel wood, and biomass wastes. The total energy demand has been obtained from different fuel sources including LPG, Fuel-wood, Animal Waste, Kerosene and Electricity. The relevant measures that have been considered while building the alternate scenario are listed in table 6 below.

Table 6: Key Assumptions for BAU and Alternate scenario

Activities	Key Assumptions for BAU scenario	Key Assumptions for Alternate Scenario
LPG for Cooking	100% in urban households by 2025 100% in rural households by 2050	100% in urban households by 2022 100% in rural households by 2030

Activities	Key Assumptions for BAU scenario	Key Assumptions for Alternate Scenario
Electricity based Induction cook-stoves for cooking	No electric cook stoves	50% electric cook-stoves by 2050, penetration starts after 2030
Fuel usage for space heating	Increase in electric heaters by 20% in 2050 in urban and 10% in rural households.	Increase in electric heaters by 50% in 2050 in urban and 20% in rural households. Biogas based space heating by 20% in 2050 in urban and 30% in rural.
Lighting	Growth in Lighting Load by 2% p.a.	Growth in Lighting Load by 2% p.a. With solar based lighting in 30% households in Rural areas
Electricity Usage for other activities including Water Heating, Appliances, etc.	Increase in per capita usage to 330kWh in urban and 180kWh in Rural	Increase in per capita usage to 450kWh In urban and 250 kWh in rural areas (increased aspirations met)
Less Energy Intensive Solar Passive Houses	Nil	10% solar Passive Houses with 80% reduction in space heating requirements.

It has been assumed that share of few clean energy options would increase in baseline scenario, due to which the total energy demand won't increase much. But the accelerated approach adopted in alternative scenario has the potential of further reduction in total energy demand by around 25%. The demand side management of energy in residential sector holds the potential to reduce substantial GHG emissions. The energy demand in two scenarios is shown in figure 10.

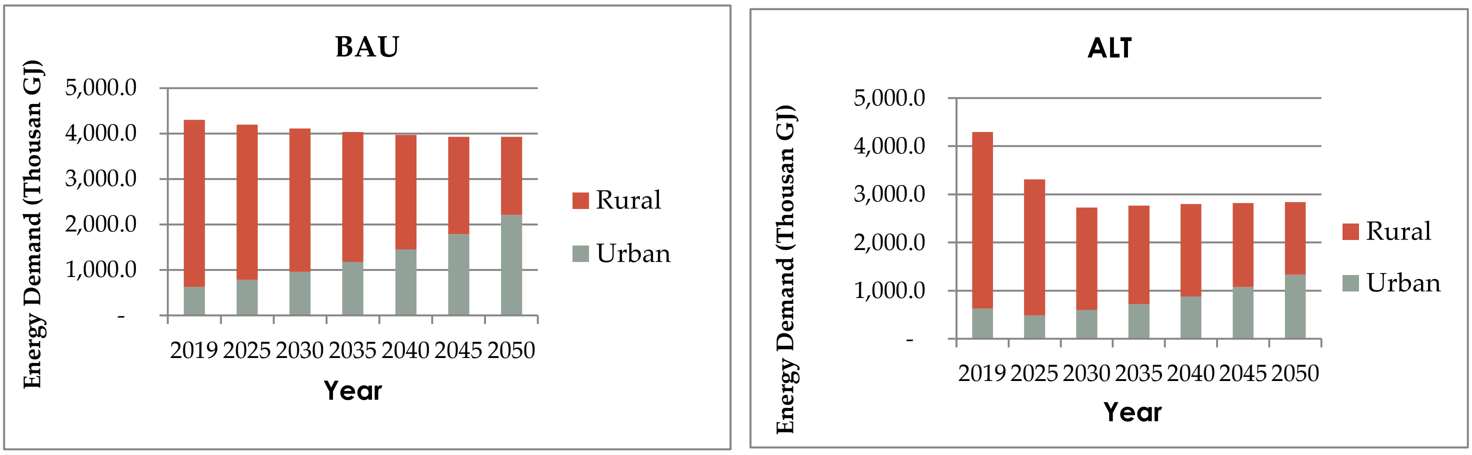


Figure 10: Energy demand in BAU and ALT scenarios

The energy demand projections under alternate scenario reveal the potential of reduction in overall demand from adopting measures discussed in table 6. Although the share of urban households increased to 60% in 2050 but the energy demand remains lesser, mainly due to the efficient alternatives taken for cooking and space heating practices.

4.4.2 Land Transport

The energy demand for land transport component of the CNAP has been examined in the following section. Land Transport is composed of mainly privately owned vehicles and tourist vehicles; public transportation is not so significant in the region, while rail services do not exist. The defense sector also holds the significant share of energy demand for land transport which has been considered in separate section for defense sector energy demand.

According to the statistical handbook, the numbers of vehicles registered are given in table 7 with the projections for 2030 and 2050. Vehicle stock has been classified under four major categories i.e. 4-wheelers, 2-wheelers, light commercial vehicle (LCV) that includes tractor, ambulance, pick up vehicles, camper , and Heavy commercial Vehicles (HCV) including Bus, truck, tipper, min truck . The projections for vehicle registrations has been done based on the available CAGR from 2013-18. It has been assumed that growth rate will decline further to 2030, as the growth rate of local population is low and the large share of vehicle stock exists to cater the tourist demand which will be significant post 2030 vehicle registration.

Table 7: Number of vehicles registered with the projections for 2030 and 2050

Vehicle Segment	Number of Vehicles (Stock in 2019)	Growth Rate (up to 2030, 2040, and 2050)	Number of Vehicles (2030)	Number of Vehicles (2050)
Four Wheelers (inc. Taxis)	16200	8.3%, 5%, 2%	38943	85250
Two Wheelers	4300	7.6%, 4%, 2%	9625	17368
Light Commercial Vehicle	4600	8%, 4%, 2%	10726	17537
Heavy Commercial Vehicles (including Buses)	2100	6.3%, 4%, 2%	4112	5537

There has been sustained growth in the region's fuel consumption needs due to the construction projects that require transportation of materials and the growing tourist's footfall. The further announcements of mega renewable energy projects and expansion of infrastructure and construction activities to accommodate tourists will lead to further growth in fuel consumption for transport.

Energy consumption projections for Land Transport

The energy demand and further emissions projections for land transport in CNAP has been estimated using a bottom up methodological approach with the following elements

- Core data to run the model includes Vehicle Stock based on vehicle segment, vehicle type, and fuel types used, annual distance driven, fuel efficiency and specific fuel consumption of the vehicle as per the type of vehicle.
- Vehicles Stock per category: Vehicle registration numbers are based on the Ladakh Road Transport Office (RTO) database; however the vehicle category has been compiled under for major categories as 2-W, 4-W, LCV and HCV. The average vehicle year is calculated based on the RTO data which includes vehicles prior to year 2000.
- Fuel types used include petrol and diesel, while dual-fuel vehicles with petrol and CNG are not used in the region. Fuel share data has not been available and assumed after consultation with RTO. The electricity based vehicles do not exist and has been used as fuel in future projections.
- The annual average vehicle kilometres (VKTs) driven is based on calibration with top-down fuel sales for petrol and for diesel. The fuel consumption in private tourist vehicles has been estimated on the basis of fuel sales data.
- Vehicle emissions are not related to speed and operating conditions as no data on these factors are available.
- The emission degradation factor has been used to account for the larger emissions arising from the older fleet. CO_2 emissions are based on the emission factor for each type of fuel usage and vehicle operated on Bharat Stage (BS) standards. (IPCC 2006 approach)

The two scenario BAU and ALT has been structured for estimation of GHG emissions from the transport sector. The scenarios envisions the gradual penetration of strong hybrid and electric vehicles in the document. The assumptions for estimations are listed in table 8.

Table 8: Key assumption for transport sector estimation

Activities	Key Assumptions for BAU scenario	Key Assumptions for Alternate Scenario
Public Transportation on EV	25% EV buses in 2050 (80% hybrid, 20% pure EV)	100% EV buses in 2050 (50% hybrid, 50% pure EV)
Electrification of 4-W	10% 4-W in 2050, penetration starting after 2030	75% 4-W in 2050, (it will start immediately)
Electrification of 2-W	No penetration of EV	100% EV based 2-W
BSVI compliant vehicle	Phasing out as per EV penetration followed by adoption of BSVI	Phasing out as per EV penetration followed by adoption of BSVI
Electrification of LCVs	10% by 2050 (80% hybrid, 20% pure EV)	75% by 2050 (50% hybrid, 50% pure EV)

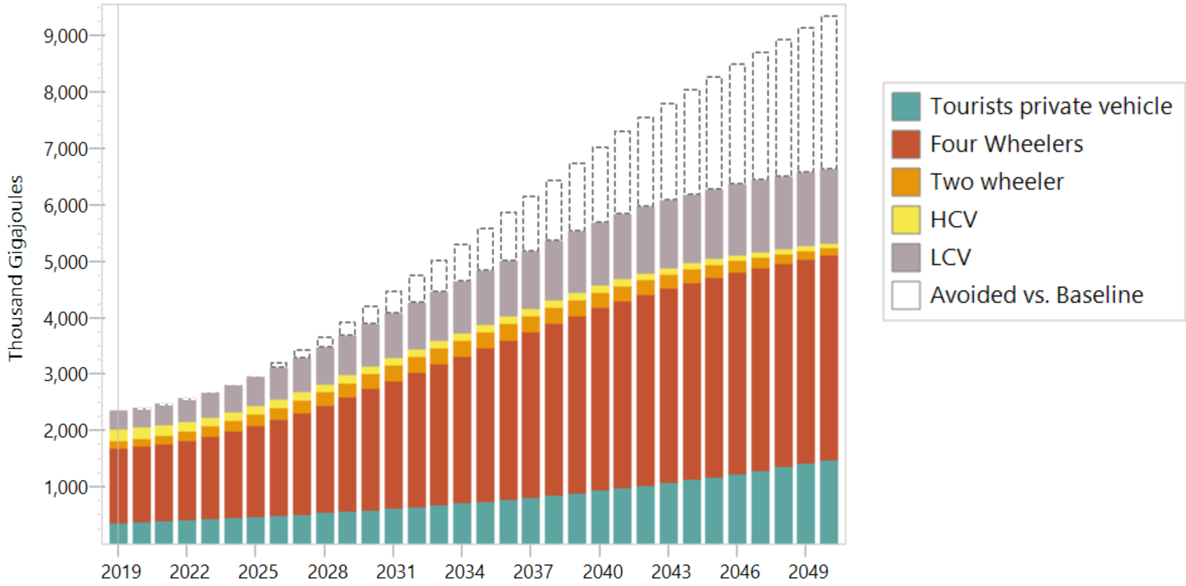


Figure 11: Energy demand for transport sector in alternate scenario

The alternate scenario in figure 11 shows the reduction in overall energy requirements in order of 33% if the electrification of vehicle is adopted more aggressively. Also the share of hybrid vehicle is assumed in significant proportion due to unproven electric vehicles in the region. However, hydrogen based EVs are not considered in the modelling while it will play important role for decarbonization of transport sector. The section on hydrogen based vehicles is discussed in chapter -5 in greater details.

Electricity Demand for mobility

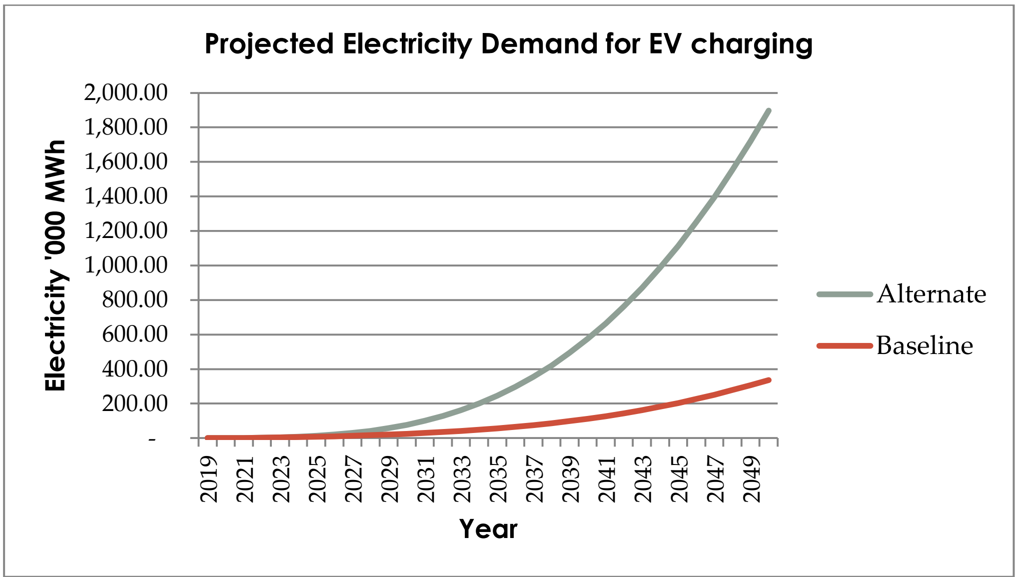


Figure 12: Projected electricity demand for EV charging

The electrification of vehicular fleet will increase the electricity demand for charging requirements; the projections for electricity are shown in figure 12. This also includes the electricity requirements for hybrid vehicles. The estimations shows under the alternate scenario where the EV penetration will undertake aggressively, electricity demand for charging can increase near to 2 Million MWh annually against the baseline scenario where it will remain as low as 0.4 Million MWh.

Peak Power Demand

The running of EV's will stress the grid in terms of electricity production, and in terms of power demand. It can have a sizeable impacts on the grid loads at certain times and locations. Managing power demand is likely to require stationary storage at local level as well centralized level, with the provisions of controlled charging as well as smart charging systems.

4.4.3 Commercial and Industries

The major categories considered under the commercial sector are the hotels, borewells and other buildings, that include public services, commercial establishments, offices and restaurants. The hotel category has been further sub-divided into different categories, guesthouses, budget hotels, mid-size, luxury and homestays. The data required for the estimation of GHG emissions from the various category of hotels is the number of each type of hotel, their growth rate and the various fuels utilized for different end-uses.

Table 9: Estimated different hotels based on the annual growth rate for each category

Sub-category	2019	2025	2050	Growth rate (in %)
Guesthouses	696	1061	2619	7.3
Budget Hotels	81	134	323	8.6
Mid-size	218	320	720	6.6
Luxury	26	35	87	4.8
Homestays	41	73	247	10

The numbers of different hotels shown in Table 9 have been estimated based on the annual growth rate for each category. The compound annual growth rates have been estimated using the past data. The number of hotels have leapfrogged in Ladakh, especially in Leh from 2011 onwards. They have grown at an annual average rate of more than 7%. There were no high-end hotels in Leh before 2011, however they increased to 25 in 2018, however the highest increase has been in the low-end hotels that increased from 33 in 2011 to 75 in 2018 (growing at an annual average rate of 8.6%).

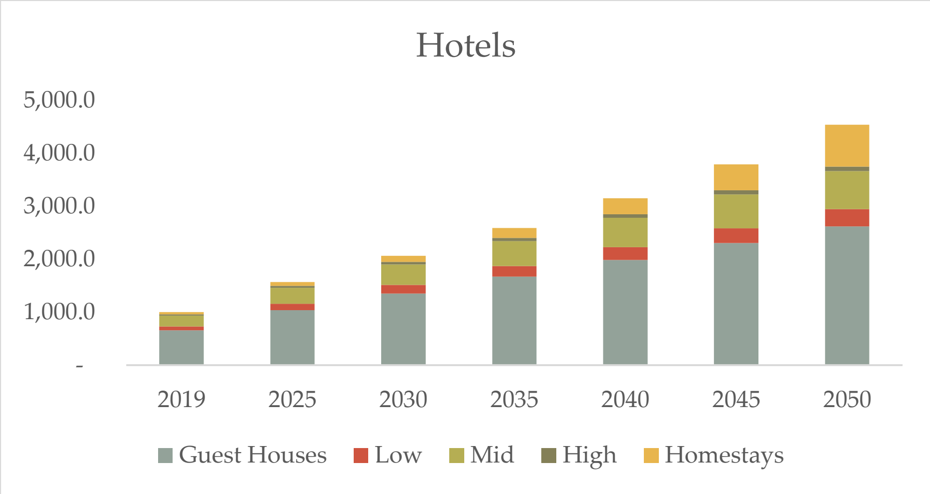


Figure 13: Number of hotels by different categories

Figure 13 shows the number of hotels by different categories. Out of all, the share of guest houses is the highest, followed by mid-end and low-end hotels. However, the share of mid-end and homestays is estimated to increase by 2050. Figure 14 shows the share of different hotel categories in total energy demand. Though the guest houses make the highest share in number, in terms of energy demand mid-hotels contribute the most. Even though the share of high-end hotels is as low as 3% in total, their share in energy demand is as high as 30% which shows that they are very energy extensive establishments. Guest houses that contribute more than 65% in total establishments, contribute only 23% in total energy demand.

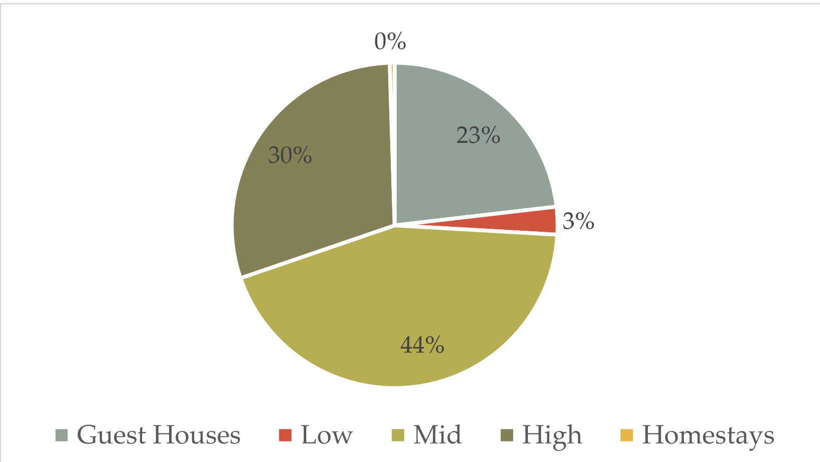


Figure 14: Share of different categories of hotels in total energy demand in 2020

The other categories included in the commercial sector are the private borewells that are used to draw water for commercial purposes and other buildings that include public services, commercial establishments and restaurants. The rising demand for water and glaring demand and supply gaps have led to increased extraction of groundwater in several parts of the UT. The installation of private bore wells have increased multifold in the last few years in Leh especially because of the hotels and guesthouses. An estimated 1,200 – 1,700 borewells have been drilled to supplement the PHE's supplies. Based on the annual growth rate of water demand, the growth rate of these private borewells is considered to be around 4.5%. The other categories include the public services like bank branches, post offices, police stations, hospitals, medical care centers, shops, schools, colleges, universities and restaurants. Out of all these categories, restaurants and commercial establishments have the highest growth rate. They have almost doubled in the past few years and are expected to increase at this rate in the future because of the rising tourism sector in the region. However, from an energy demand perspective, restaurants are the most energy extensive in the BAU scenario.

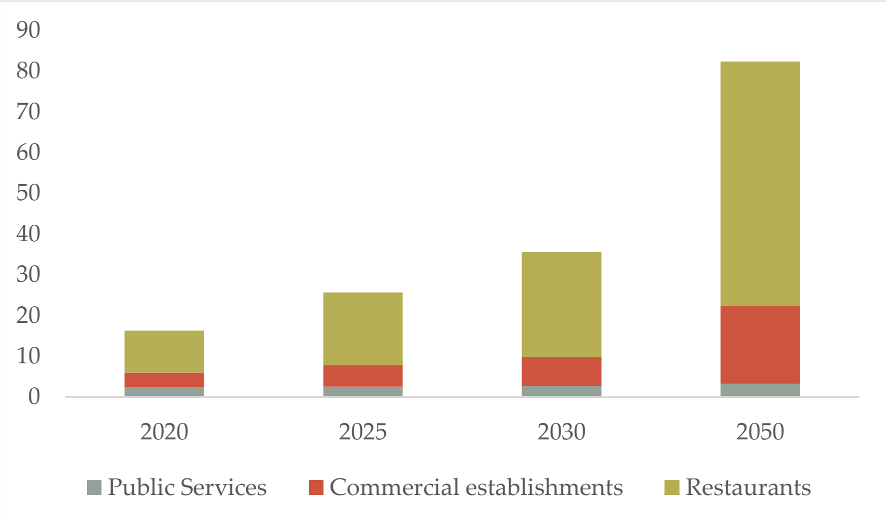


Figure 15: Energy demand of public services, commercial establishments and restaurants (in million kWh)

The assumptions for projecting future energy demands vary for the BAU and the ALT scenario. Table 10 summarizes the assumptions both in the BAU and ALT scenario on various energy intensive activities and fuel mix.

Table 10: BAU and ALT scenario on various energy intensive activities and fuel mix

Energy Intensive Activity	BAU	ALT
Borewells	Share of solar water pumping system by 20% in 2050	Share of solar water pumping system by 50% in 2050
Electricity in Hotels	Decrease in DG based electricity by 50%	Decrease in DG based electricity by 80%
Space Heating in Hotels	Increase in share of electricity by 50%	Increase in share of electricity by 80%

The assumptions show that more of conventional fuels are used in the BAU scenario compared to the ALT scenario which will lead to more energy demand and then emissions in the BAU scenario.

4.4.4 Urban Management

Under urban management, two categories have been included, water and street lighting. The demand for water in the region has been rising in the past few years because of the rising tourist influx, the increasing number of commercial establishments like hotels and guest houses, and even the changing patterns of consumption of water. Out of all the various sources of water, the dependence on snow melted water and springs have substantially declined in the past few decades, increasing dependence on groundwater especially in few parts of Leh district. Even major variations persist in the consumption of water according to consumers and seasons. The average water consumption of a tourist is estimated to be more than the average water consumption of a local and almost twice of a migrant.

Here the public supply of water has been considered which comes through public tube wells and Indus tube wells. There are in total 12 PHE owned tube wells out of which one is situated in Kargil and the rest 11 are in Leh. The total number of operating pumps are 18 that majorly run-on diesel. The average annual consumption of diesel for operating one tube well in Kargil is around 40,000 liters and the average annual consumption of diesel for operating 11 tube wells in Leh is around 24,000 litres. The tubewells are completely operated on diesel in Kargil and no electricity is used there, however around 83,000 kWh of electricity is utilized to operate 11 tube wells in Leh. Therefore, the baseline data for estimating energy consumption for water supply has been summarized in Table 11.

Table 11: Baseline data for estimating energy consumption for water supply

Indicator	Leh	Kargil
Number of water pumping stations	11	1
Average annual volume of water Extraction (litres)	585 lakh gallons	114.65 lakh gallons
Average annual volume of Diesel /Electricity Consumption for PHE tube wells	Diesel- 24,000 litres Electricity- 83,000 kWh	Diesel- 40,000 litres
Number of operating pumps	11	7
Average water consumption by a local- 62 litres per day *Average water consumption by a tourist - 104 litres per day* ** This accounts for seasonality*		

The key assumptions for estimating the energy demand for water supply and street lighting in both the scenarios BAU and ALT are summarized in Table 12.

Table 12: Estimate demand for water supply and street lighting in BAU and ALT scenarios

Sector	BAU	ALT
Water	Use of both electricity and diesel-based water pumping	Use of only electricity-based water pumps by 80% in 2050

	Growth rate of water demand- 4.2%	
	Estimated water consumption in 2020- 9 MLD Estimated water consumption in 2050- 21 MLD	
Street Lighting	Use of electricity (grid based) and diesel for street lighting	Share of electricity (grid based)- 75% Share of solar based street lighting- 25%

The key assumptions under the BAU and ALT scenario indicate that more of electricity based operating pumps will be utilized in the ALT scenario compared to the BAU. For street lighting, no renewable based energy is used to run them in the BAU scenario, however it has been assumed that the share of solar based street lighting will increase to 25% and the use of diesel will be totally eliminated from the ALT scenario.

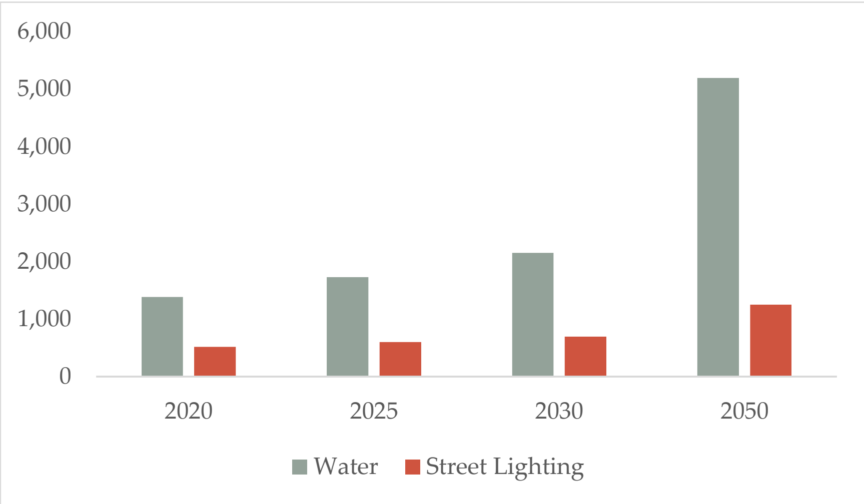


Figure 16: Energy demand in water supply and street lighting in BAU (in thousand kWh)

The total energy demand of water supply and street lighting together is estimated to be 1,800 thousand kWh in 2019 which will increase to 6,800 thousand kWh in 2050 under the BAU scenario.

4.4.5 Defense

Ladakh being an important location for the presence of defence forces, poses a lot of infrastructural requirements for them. These basic requirements for the defence include transportation, cooking, space heating and lighting. The major fuels of energy are kerosene and wood which are mainly used for space heating, followed by diesel for transportation, LPG for cooking and electricity for various uses. The data on the kerosene, wood and LPG consumption have been taken from the Statistical Handbook and are based on per capita fuel consumption. The vehicles used for transportation by defence have been assumed to not adhering to any pollution control standards and norms.

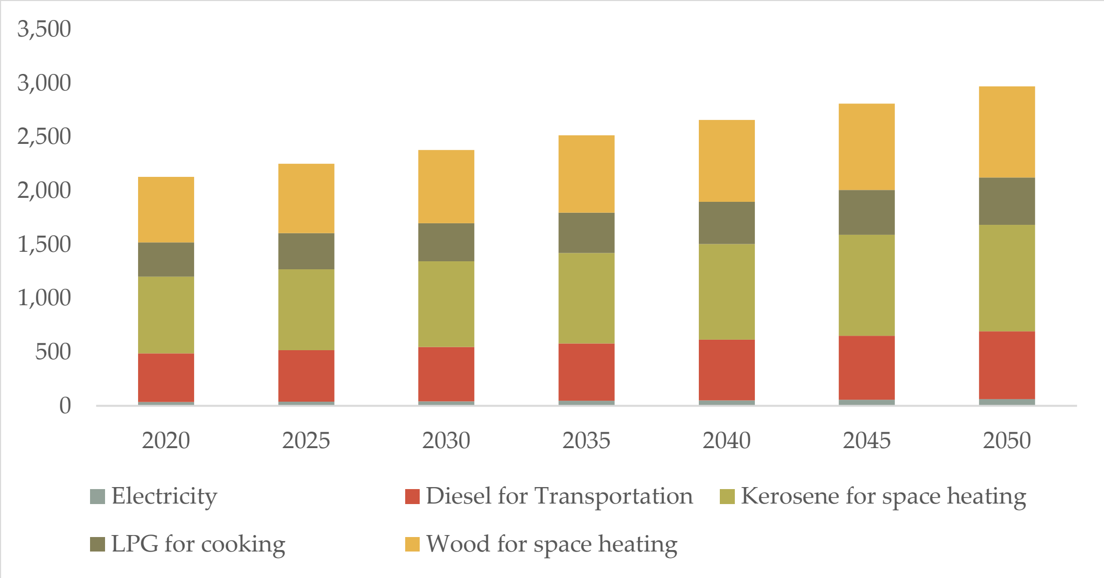


Figure 17: Total Energy demand (in thousand Gigajoules)

Out of all the sources of energy utilised in the defence sector, the use of kerosene for space heating constitutes the maximum share of the total energy demand, followed by wood for space heating as well. The use of diesel for transportation is another major category of fuel usage followed by LPG for cooking purposes.

4.5 Electricity

The supply of electricity has been projected and modeled based on two major assumptions i.e. one to fulfill the total demand indigenously, and other to harness the available potential of renewable energy and to penetrate the excess electricity generated in grid. The total electricity demand is estimated for discussed sectors based on the electrification of energy intensive activities and appliances. The use of diesel gen-sets for electricity generation is planned to be completely phased out as both economically and environmentally undesirable. But will continue to remain the integral part to address the flexibility issues to cater to the demand across different seasons and time of day.

The current available electricity generation is largely based on the hydro power, diesel based gen sets, and the production from solar is still miniscule while the remaining deficit in winters is sourced from the Srinagar transmission network. The amount of grid electricity generated in 2018 is based on the Power development department (PDD) data while the average availability factor for the generation processes was assumed based on the historical production trends, for e.g., the availability of hydro power reduces to only 30% of its production capacity due to freezing of rivers.

Production capacities under two scenarios: The generation capacity projected under two scenarios are based on the potential of generation and policy priorities of the region, a total of 35GW of solar generation potential is assessed in the region. Further details for the sources of electricity generation are as follows:

Solar: A cumulative capacity addition of 10 GW is expected to be commissioned by 2050 under baseline scenario, while the 1.5 GW of capacity installations is expected to be achieved by 2025. Whereas, the full potential exploitation of 25GW is assumed under alternate scenario. The solar plant is assumed to operate under must run status where electricity which is not been able to consume indigenously because of technical constraints to address flexibility issues, or insufficient demand will be directed to national grid.

Hydro: Currently, small hydro plants are catering to almost 90% of grid based electricity needs excluding the imports in winter season. The cumulative capacity of 250 MW is expected to exist in year 2050 under BAU scenario, while a total of 395 MW (which is total assessed potential) of capacity is assumed in alternate scenario.

Diesel: The diesel based generation capacity is assumed to be increased to 100 MWW under BAU scenario, while it will be increased to 50 MW under ALT scenario. The diesel based generation under alternate scenario will increase up to 2025 to cater to growing demand, whereas afterward it will decrease gradually to zero in 2050 with energy storage infrastructure in place.

Other RE (including wind, geothermal): The estimated potential of wind and geothermal energy is assessed at 5GW and 200 MW respectively. However no electricity generation is considered in modelling exercise, while capacity of 1 GW of wind energy and 100 MW of geothermal can be targeted up to 2050. The capacity addition is considered beyond 2030, till than feasibilities studies and pilots are expected.

Energy Storage: The energy storage of 100 MWh is considered in 2050 under alternate scenario to completely phase out the diesel based electricity generation that will be required during the peaking requirements to address the flexibility issues.

Table 13: Installed Capacity

BAU	ALT
Solar- 7.5 GW (2050)	*Solar- 25 GW (2050)*
Solar – 1.5 GW (2025)	*Solar – 4.5 GW (2025)*
Hydro- 250 MW	*Hydro- 395 MW*
DG sets- 100 MW	*DG sets- 50 MW*
	Exogenous Energy Storage- 100MWh

Electricity Generation:

Table 14: Electricity generation from the available sources

Process	Installed Capacity (MW)	Electricity Generation (MWh)
DG	45	5914
Hydro	113.5	183286
Solar	2.1	-

The electricity generation from the available sources presently is given in table 14. Hydro has been the predominant source for the electricity supply in the region while the solar is currently used at decentralized level majorly for far flung areas, the diesel based generation is also significant. The electricity generation from available from available technologies has been projected given the following assumptions:

- The dispatch rule for RE technologies is considered as Full capacity run, wherein excess electricity will be exported to national grid. The dispatch from diesel is assumed as per the current demand and process share based on the historical production.
- The adequate grid infrastructure for evacuation is assumed.
- A gradual decrease in T&D losses of 20% and 15% has been considered under BAU and ALT scenario respectively by 2050
- A total of 35% reserve planning margin is considered while conducting the generation analysis.

The total electricity generation under BAU and ALT scenario is presented in figure 18.

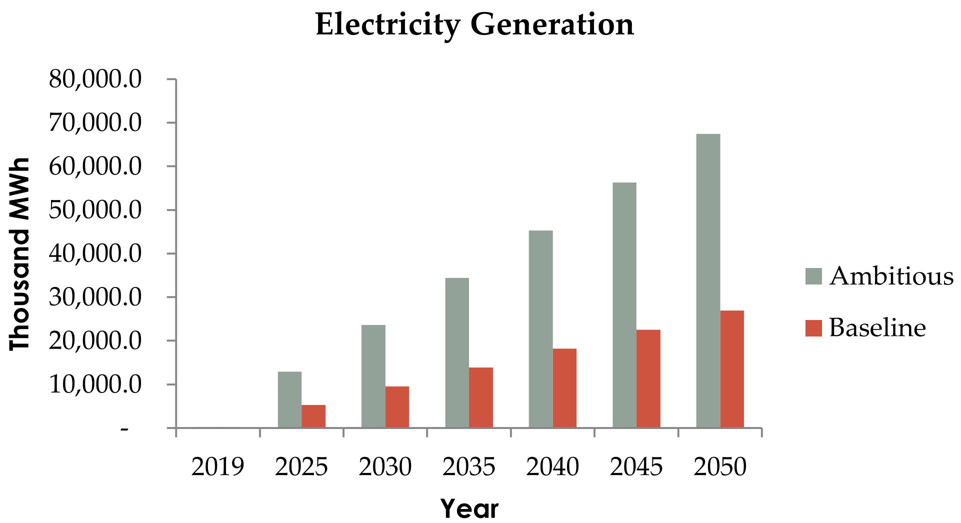


Figure 18: Total electricity generation under BAU and ALT scenario

The total electricity generation will by far exceed the domestic requirement in both the cases, considering the full capacity generation from large solar installations. The export potential of electricity is around 65 Million MWh under ALT scenario and 26 Million MWh under BAU scenario.

Table 15: Module Energy balance (in 2050)

Module Energy Balance, 2050	ALT	BAU
Imports	-	-
Outputs	67.4	26.9
Domestic Requirements	2.5	0.8
Exports	64.9	26.1
Unmet Requirements	-	-

4.6 Total energy Demand Projections

The previous sections shows demand projections for various sectors under BAU and ALT scenarios. The total fuel-wise energy demand currently and by 2050 under both scenarios is shown in below figures. The total energy demand can be reduced significantly if the clean energy and efficient measures are adopted with strategic planning as under the accelerated alternate scenario.

As per the current estimates for the total energy demand based on the fuel usage and type of appliances, Ladakh is a domestic heavy region contributing to the 46% of total energy demand. The transport and defense sector are the other major sectors for total energy demand. While the fuel-wood, diesel, animal wastes, and kerosene are predominant fuels on which the region is dependent, the share of electricity and LPG is very low currently.

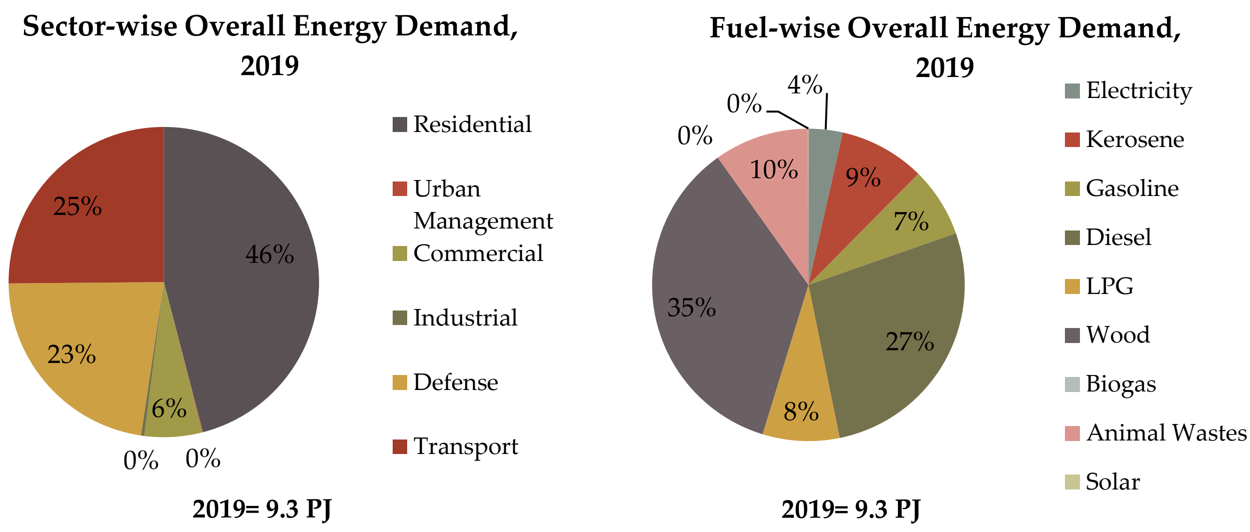


Figure 19: Sector wise fuel wise overall energy demand 2019

The baseline scenario shows the demand projections based on the government policy priorities for the region, where in all the key interventions will be implemented. However, in alternate scenario these interventions will be implemented in an accelerated manner having more ambitious targets.

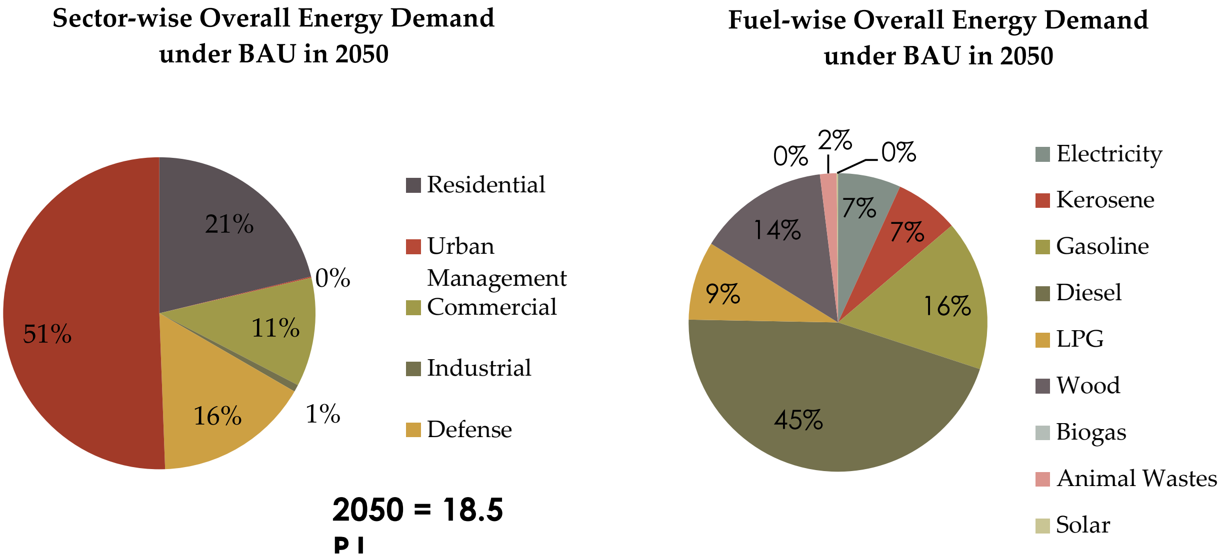


Figure 20: Sector-wise Fuel-wise overall energy demand under BAU in 2050

Under, baseline scenario the total energy demand will increase to almost double as of now, wherein it has been assumed the efficient practices related to fuel usage will be adopted across all sectors excluding defense. The transport sector will account for the major energy demand owing to increase in tourists footfall. While the diesel will remain the major fuel that will be required in transport as well as defense sector.

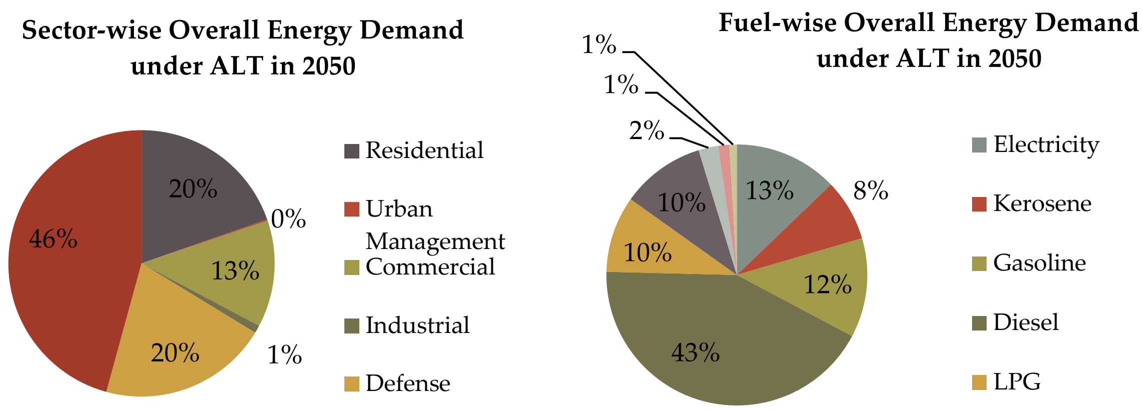


Figure 21: Sectorwise Fuel-wise overall energy demand under ALT in 2050

The energy demand projection in alternate scenarios shows the potential in reduction of total energy demand by around 25%. The key sectors for managing demand will be residential and transport sector while the commercial sector should be addressed through implementation of stringent regulatory measures further discussed in following chapter.

4.7 Agriculture sector in Ladakh- GHG emissions

The agriculture sector is an important source of GHG emissions namely methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2). The CO_2 emissions in the agriculture sector emanate mainly from energy use (fuel combustion) in the agriculture sector, and as other GHG emissions such as CH_4 and N_2O emissions from non-energy use. Methane is produced in soil during microbial decomposition of organic matter under anaerobic conditions. Burning of crop residues also contributes to methane emissions. Further, enteric fermentation from ruminants is another major source of methane.

The main source of N_2O from agriculture is through nitrogenous fertilizer application in fertilized soils and indigenous soil nitrogen in unfertilized soils. Generally, an increase in N_2O emissions is observed following irrigation and precipitation. Burning of crop residues also contributes to global N_2O.

4.7.1 Methodology

In the agriculture sector, estimation and projection of methane (CH_4) and nitrous oxide (N_2O) emission are considered. Methane emissions from enteric fermentation and manure management have been taken into consideration. Nitrous oxide emissions emanating from manure management and agricultural soils have been estimated and projected. As there is no rice cultivation in Ladakh and also field burning of agricultural residues is not a common practice in Ladakh, these have not been considered for GHG emission estimation.

A bottom up accounting framework comprising of various activities leading to GHG emissions has been used for estimation and projection of GHG in the agriculture sector. The study mainly used the emission coefficient relevant to the Indian conditions and wherever not available, appropriate IPCC default emission factors have been applied. Estimation and projection of emissions from each of the individual sectors has been conducted within an integrated framework and based on common broad assumptions.

4.7.1.1 Livestock Emissions

GHG emissions from livestock have two components: i) Methane emission from enteric fermentation and manure management, and ii) nitrous oxide from animal waste management system.

Methane from Enteric Fermentation and Manure Management

Population figures of different livestock categories in Ladakh for 2017 were used as the basic activity data. The livestock considered in this estimation include Cattle, Sheep, Goats, Zo/Zomo and Yaks, Horses/Ponies/Donkeys/Mules and Camel. For future projection of livestock populations under different categories, data from 2007 and 2016 has been used. Age distribution and hence the weight of animals was applied while estimating enteric fermentation. The cattle population has been divided into dairy and non-dairy categories, with sub classification into indigenous and cross-bred types, based on Singh (2014).

Emission factors provided in the India's Second National Communication for cattles, buffaloes and sheep and emission factors based on Patra (2012) have been applied.

Nitrous oxide Emissions from Animal Waste Management Systems

Nitrous oxide emission from manure management is due to conversion of manure nitrogen into nitrous oxide during storage. Out of the 6 different Animal Waste Management Systems (AWMS) only anaerobic lagoons, liquid systems and other systems qualify under manure management and the remaining AWMS is reported under agricultural soils. According to IPCC guidelines, cattle (dairy and non-dairy), pigs and poultry only account for the nitrous oxide emissions and other animals which do not account for manure management under wet system, are eliminated from the category of animals producing N2O from AWMS. Nitrogen excretion values have been taken from India specific calculations. Default values for percentage of manure nitrogen produced in different AWMS is taken form IPCC. IPCC default emission factor for Asia for different AWMS is taken for estimating N_2O emission per animal.

4.7.1.2 Emissions from Agricultural Soils

Agricultural soils contribute towards the emission of CH_4 (mainly from paddy fields) and N_2O (from N-fertilizer application). Emissions of N_2O that result from anthropogenic N inputs occur through both a direct pathway and through two indirect pathways of volatilization and leaching. Direct emissions from agricultural soils is estimated using net N additions to soils comprising of - Annual amount of synthetic fertilizer N applied to soil, Applied organic N fertilizer other than grazing, Amount of N in crop residue returned annually, Amount of N mineralized from loss in soil organic C in mineral soils through land use change or management practices. The indirect N_2O emission was estimated from volatilization of ammonia (NH_3) and nitrogen oxide (NOx) from the N additions to soils and the subsequent redeposition of these gases and their products (NH_4 and NO_3) to soils. The indirect N_2O emissions were also estimated from leaching and runoff of N, mainly as NO_3 from fertilized soils.

Data on synthetic fertilizer N consumption for different years was obtained from District Statistical Handbook. Five categories of livestock viz., cattle, buffalo, sheep, goat, camel and poultry have been taken for the inventory for calculating annual amount of animal manure nitrogen applied to soils other than by grazing animals.

Nitrogen excretion values for each livestock category annually have been calculated using data from the following sources. Data on dung produced per bovine per year was obtained from Pathak et al. (2009), and dung produced by sheep, goat, and camel was reported by Gaur (1995). N content in bovine dung was taken as 1.0% and in sheep and goat dung as 1.87% (Subrian 2000) and N content in poultry dung was taken to be 2.2 % (Amanullah et al. 2007). Fraction of animal manure that is burned for fuel, fraction of animal manure that is deposited on to soil by grazing livestock and, fraction of animal manure that is used for construction is taken from Gaur (1995).

Fraction of poultry manure that is being used as feed has been gathered from Bhatia et al. (2013). Fraction of loss during collection of dung has been taken from TERI (2013). The fraction of grazing animals has been based on the assumption that only 10% of animals go for grazing for approximately three months a year. Out of the dung deposited while grazing, only approximately 10% is left on the field and rest is removed from the field for fuel and construction (Bhatia et al. 2013).

4.7.2 GHG inventory of the Agriculture Sector in Baseline and Alternative Scenarios

The reference scenario indicates that the policies and programmes of agriculture sector will be realized according to observed trends in terms of crop area and productivity and livestock population. It also ensures that food demand in terms of quantity and nutrition as indicated in the literature and policy documents is fulfilled. The reference scenario also takes into consideration net sown area, cropping intensity and synthetic fertilizer consumption predicted by the concerned Government agencies.

Alternative Scenario ensures that food demand of the population in the future is met as well as farmers have choices of crop diversification as per the market demand. Also, total livestock population will be marginally decreasing as compared to reference scenario, but it will be able to satisfy the demand for livestock based products and other livestock related demands due to increase in productivity and improved technological interventions. Under this scenario, fertilizer consumption will show a declining trend as compared to reference scenario. Here more emphasis will be given for balanced use of fertilizers. Share of compost, green manure and bio-fertilizers will show a significant increase under this scenario.

Under Reference Scenario, as shown in Table 16, methane emissions from enteric fermentation increases from 151.7 Gg CO_2 eq. in 2017 to 235.0 Gg CO_2 eq. in 2050. Methane emissions from manure management are estimated at 11.5 Gg CO_2 eq. for 2017 and increases to 13.6 Gg CO_2 eq. in 2050.

Emissions of nitrous oxide is projected to increase from 1.9 Gg CO_2 eq. in 2017 to 3.4 Gg CO_2 eq. in 2050. Emissions of nitrous oxide from agricultural soils was estimated to be 6.2 Gg CO_2 eq. in 2017 to 12.4 Gg CO_2 eq. in 2050.

Under Alternate Scenario, as shown in Table 17, total emissions is estimated to decline from the baseline scenario by around 9% to 167.9 Gg CO_2 eq. in 2030, and by around 30% to 185.8 Gg CO_2 eq. in 2050.

Table 16: Emissions from agriculture sector in Ladakh under baseline scenario (Gg CO_2 eq.)

	Methane emission			Nitrous oxide emission			Total emission		
	2017	2030	2050	2017	2030	2050	2017	2030	2050
Enteric fermentation	151.7	166.3	235.0	-	-	-			
Manure management	11.5	11.3	13.6	1.9	1.9	3.4			
Agriculture soils				6.2	6.2	12.4			
Total	163.2	177.5	248.6	8.1	8.1	15.8	171.3	185.6	264.4

Table 17: Emissions from agriculture sector in Ladakh under alternate scenario (Gg CO_2 eq.)

	Methane emission		Nitrous oxide emission		Total emission	
	2030	2050	2030	2050	2030	2050
Enteric fermentation	149.6	164.5	-	-		
Manure management	10.2	9.5	1.86	2.48		
Agriculture soils			6.2	9.3		
Total	159.8	174.0	8.1	11.8	167.9	185.8

4.8 Overall Emissions

The energy demand estimations in the various sectors and sub-sectors are followed by the GHG emission inventory using the emission factors for different fuels. The emissions have been estimated both across sectors and fuel type and under BAU as well as ALT scenario. Table 18 shows the sector wise emission inventory in the BAU scenario.

Table 18: Sector wise emission inventory in BAU scenario (in kilo tonnes CO_2 equivalent)

Sector	2019	2025	2030	2035	2040	2045	2050
Residential	65	69	73	77	82	86	91
Commercial	34	48	62	76	91	106	121
Urban Management	0.2	0.2	0.3	0.4	0.4	0.5	0.7
Defence	114	122	128	136	144	152	161
Agriculture	175	180	186	205	225	245	264
Transport	168	211	293	388	488	573	647
Electricity	7	34.6	39.1	43	46.3	48.7	49.9
Total	**563.2**	**630.2**	**742.3**	**882.4**	**1030.4**	**1162.5**	**1284.7**

The sector wise emissions show that out of all the sectors, the agricultural sector has the maximum contribution to the total GHG emissions of Ladakh which is because of the major contributions from the non-energy sectors than the energy sectors. The emissions from the agricultural sector are followed by the emissions from the transport sector wherein the four wheelers or the taxi vehicles have the maximum contribution. Seeing the exponential growth of tourists in the region, the total emissions from the transport sector are expected to surpass the emissions from the agricultural sector in 2030. Table 19 summarizes the sector wise emission inventory in the ALT scenario.

Table 19: Sector wise emission inventory in ALT scenario (in kilo tonnes CO_2 equivalent)

Sector	2019	2025	2030	2035	2040	2045	2050
Residential	65	63	67	69	69	67	62
Commercial	34	44	54	63	72	81	90
Urban Management	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Defence	114	122	128	136	144	152	161
Agriculture	175	171	168	172	177	181	186
Transport	168	204	257	302	331	334	340
Electricity	7	33.9	36.2	35.9	31	19.7	0
Total	**563.2**	**638.1**	**710.4**	**778**	**824**	**834**	**815**

Under the ALT scenario, the total emissions increase by 63% between 2019 and 2050 which increase by 128% in the BAU scenario. Of all the sectors, the transport sector will have the maximum share in the total emissions followed by the agricultural sector. Overall, the total emissions reduce by almost 40% in 2050 in the ALT scenario compared to the BAU.

Similar to the sector wise emissions, the fuel wise emissions have also been estimated from various sectors. Table 20 shows the fuel wise emissions in the BAU scenario and Table 21 shows in the ALT scenario. However these fuel wise emissions do not include non-energy emissions from the agricultural sector.

Table 20: Fuel wise emissions in the BAU scenario (in kilo tonnes CO_2 equivalent)

Sector	2019	2025	2030	2035	2040	2045	2050
Kerosene	63	68	73	78	84	90	97
Diesel	183	226	293	369	451	525	593
LPG	51	62	71	81	90	99	107
Wood	25	23	21	19	18	17	17
Biogas	0	0	0	0	0	0	0
Gasoline	48	65	94	126	159	185	206
Animal waste	7.7	6.2	5	3.6	2.3	1.0	0
Total	**378**	**450**	**557**	**684**	**825**	**961**	**1092**

In the fuel wise emissions, the share of diesel is the highest (67%) till 2050 under the BAU scenario because of the increased use and demand of diesel in the region. This is followed by the increased demand for gasoline because of its increased use in the transport sector.

Table 21: Fuel wise emissions in the ALT scenario (in kilo tonnes CO_2 equivalent)

Sector	2019	2025	2030	2035	2040	2045	2050
Kerosene	63	63	66	70	74	77	81
Diesel	184	218	267	317	363	397	423
LPG	51	70	84	87	89	90	89
Wood	25	15	8	8	9	9	11
Biogas	0	3.4	6.1	8.6	10.8	12.3	12.8
Gasoline	48	63	84	103	118	122	117
Animal waste	7.7	3.0	-	-	-	-	-
Total	**379**	**449**	**565**	**706**	**870**	**1,027**	**1,178**

In the ALT scenario, the highest share in the fuel wise emissions is of diesel followed by gasoline both in 2020 and 2050. However, unlike the BAU scenario, the share of electricity increases multi folds under the ALT scenario and the use of animal waste and wood almost become negligible. Even the share of biogas that was not in the BAU scenario, can be seen in the ALT scenario.

4.9 Carbon storage and sequestration in forest in Ladakh

4.9.1 Carbon stock in forest land

The forests have great potential to sequester carbon primarily through conservation of existing forests, reforestation and agro forestry. Estimation of total carbon present in the forest ecosystem is required to find the total carbon sequestration in forest ecosystem. The major carbon pools of the forest ecosystem are: Above Ground Biomass (Stem wood, branch wood, bark, foliage, seeds etc), Below Ground Biomass (Coarse root, fine root & stumps), Deadwood (Coarse and fine), Soil Organic Matter &Leaf Litter, Grass and Herb.

IPCC GPG 2003 has been used for estimation of carbon stock in different pools. The summary equation, which estimates the annual removals from forestland with respect to changes in carbon pools is given below:

$\Delta CFF = (\Delta CFFLB + \Delta CFFDOM + \Delta CFFSoils)$

Where,

ΔCFF = annual change in carbon stocks from forest land, tonnes C yr-1

$\Delta CFFLB$ = annual change in carbon stocks in living biomass (includes above- and belowground biomass) in forest land; tonnes C yr-1

$\Delta CFFDOM$ = annual change in carbon stocks in dead organic matter (Dead Wood and Litter) in forest land; tonnes C yr-1

$\Delta CFFSoils$ = annual change in carbon stocks in soils in forest land; tonnes C yr-1

Forest type information has also been used for stratification of forest cover into different forest types and canopy densities. An assessment of Growing stock, Biomass and Carbon stock of Indian forests strata wise have been made by FSI based on SFR, 2011 data base. Based on FSI report 2019, the total forest area in Ladakh is 2,48,900 ha (Kargil - 2,42,962 ha; Leh – 5966 ha). The estimated component wise change in carbon stock from forest sector in Ladakh during 2017 and 2019 is given in Table 22.

Table 22: Component wise change in carbon stock in Leh and Kargil between 2017 and 2019

Carbon pools	Carbon stock in forest in 2017		Carbon stock in forest in 2019		Net change in carbon stock		Annual change in carbon stock	
	Kargil	Leh	Kargil	Leh	Kargil	Leh	Kargil	Leh
Above-ground biomass (tonnes)	10908555	230277	10974594	269484	66039	39208	33019	19604
Below-ground biomass (tonnes)	2980110	62909	2998151	73620	18041	10711	9021	5356
Dead wood (tonnes)	84525	1784	85037	2088	512	304	256	152
Litter (tonnes)	352590	7443	354725	8710	2135	1267	1067	634
Soil organic matter (tonnes)	13115865	276872	13195266	324013	79401	47141	39701	23571
Total C (tonnes)	27441645	579286	27607772	677917	166127	98631	83064	49315
Total Ladakh C (million tonnes)	**28.02**		**28.29**		**0.26**		**0.13**	

The carbon stock of Ladakh's forest for 2019 has been estimated 28.2 million tonnes. There is an increase of 0.26 million tonnes of forest carbon stock in Ladakh as compared to the carbon stock for 2017. The annual increase of carbon stock in Ladakh is estimated 132.3 thousand tonnes (83 thousand tonnes in Kargil and 49.3 thousand tonnes in Leh) which is 485 gigagrams of CO2 equivalent. Soil organic carbon is the largest pool of forest carbon accounting for (47.8%) followed by Above-ground biomass (39.8%), Below-ground biomass (10.9%), Litter (1.3%) and Dead wood (0.3%).

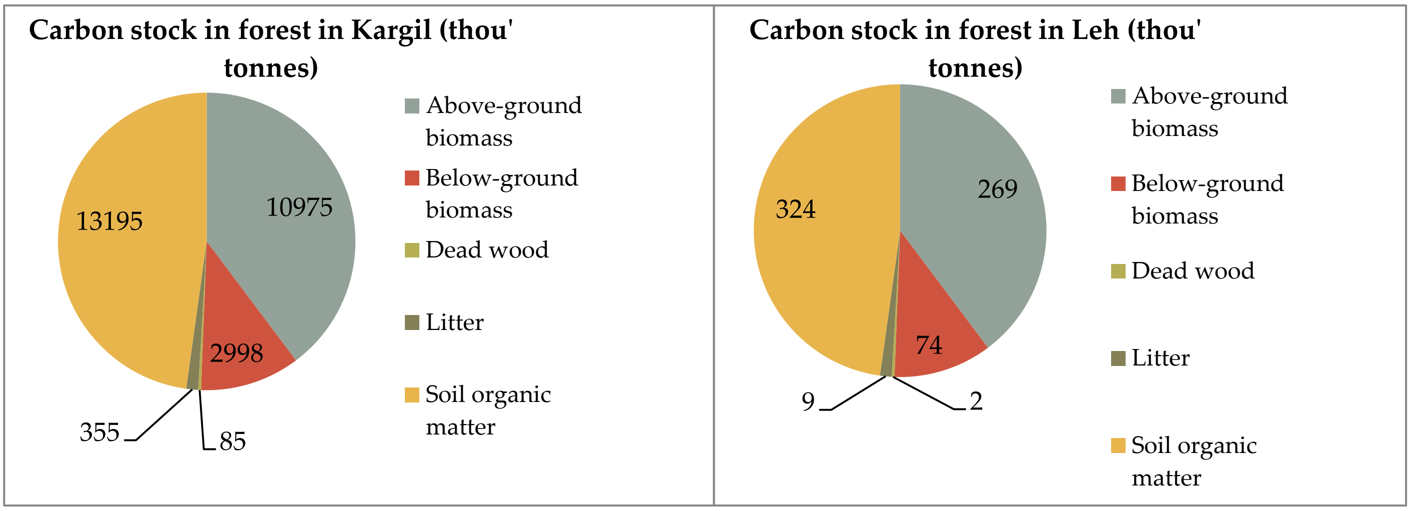


Figure 22: Carbon stocks in forest in Kargil and Leh

4.9.2 Carbon sequestration status and potential

For temperate forest regions the calculated average carbon sequestration rate is 2.4 +/- 0.8 tC ha^{-1} yr^{-1} (McGuire, 2010). The IPCC estimated that the rate of carbon gain poplar, willow which are highly sustained species in Ladakh region and other plantation as 0.2–3.1 tC ha^{-1} yr^{-1} (IPCC, 2000). Assuming that C is sequestered at least at the rate of of 1 tC ha^{-1} yr^{-1}, carbon sequestration by forestland in Ladakh is estimated 912.7 gigagrams of CO2 equivalent (890.9 $GgCO_2$equiv. in Kargil and 21.9 $GgCO_2$equiv. in Leh).

In consideration of interventions aimed at sequestering CO_2, initial emphasis on afforestation of cold resistant agroforestry species in Ladakh like poplar, willow and bushes like *Atriplex hortensis, Ephedra gerardiana, Hippophae rhamnoides, Sophora moorcroftiana, Tanacetum tibeticum, Rosa webbiana, Berberis ulcina, Myricaria germanica, Tamarix gallica* have the potential to gain biomass and sequester carbon in larger quantities as well as restore degraded lands and improve soil organic carbon (Kumar et al., 2009). Effectiveness of the forest to sequester carbon is proportional to mean annual increment. Increase in annual productivity of plantations directly indicates an increase in forest biomass and hence higher carbon sequestration potential.

Based on Wasteland Atlas of India 2019, the total wasteland in Ladakh is 58,20,784 ha (Kargil – 13,97,012 ha; Leh – 44,23,772 ha). Out of the total wasteland area, cultural wasteland area of 3,60,522 ha is considered (Kargil – 22,989 ha; Leh – 3,37,533 ha) for determining carbon sequestration potential in Ladakh. This includes area under gullied and/ or ravenous land, land with dense and open scrub, land affected by salinity/alkalinity, and under-utilised/degraded forest. Making certain assumptions about land use choices, carbon sequestration potential of continual forest growth has been determined under two scenarios. In the first scenario, assuming continual forest growth in at least 25 percentage of culturable wastelands in Ladakh and considering that C is sequestered at least at the rate of of 1 tC ha^{-1} yr^{-1} the carbon sequestration potential has been determined as 330 $GgCO_2$equiv. In the more ambitious scenario, where continual forest growth is assumed in at least 50 percentage of wastelands in Ladakh and considering that C is sequestered at the rate of 2 tC ha^{-1} yr^{-1} due to adoption of sustainable forest management practices and increase in annual productivity of plantations, the carbon sequestration potential has been determined as 1321 $GgCO_2$equiv (Table 23).

Table 23: Overview of carbon sequestration status and potential in Ladakh

	Carbon sequestration in Kargil ($GgCO_2$equiv.)	Carbon sequestration in Leh ($GgCO_2$equiv.)	Total carbon sequestration in Ladakh ($GgCO_2$equiv.)
Baseline	890.9	21.9	912.7
Additional carbon sequestration potential - Scenario 1	21.07	309.41	330
Additional carbon sequestration potential - Scenario 2	84.29	1237.62	1321

4.10 Net GHG Accounting and State of Carbon Neutrality

The aggregate GHG emissions are presented in Figure 23. The present study CNAP assesses the current state of Ladakh as carbon negative. The low carbon footprints of Ladakh are attributed to the low level of development in the region, which after the elevation of Ladakh as UT is expected to rise faster than the trend seen in the past few years. As per the current trends, under baseline scenario Ladakh will lose its carbon neutral status near to year 2035. The aggressive development and increasing tourist arrival can accelerate the emission loads and Ladakh may become carbon positive sooner.

Low emission development is explicitly stated as the driver of carbon neutrality, which will majorly include the pathways devised in the alternate scenario. The region continues to stay carbon negative till 2050 under this scenario. Whereas some potential disruptive technologies and fuels has not been considered in these estimation, which holds the potential to reduce overall region's emission substantially. It can be noted that below presented analysis did not account for the carbon offsets which will be gained while exporting the excess electricity that will be generated through large RE capacity.

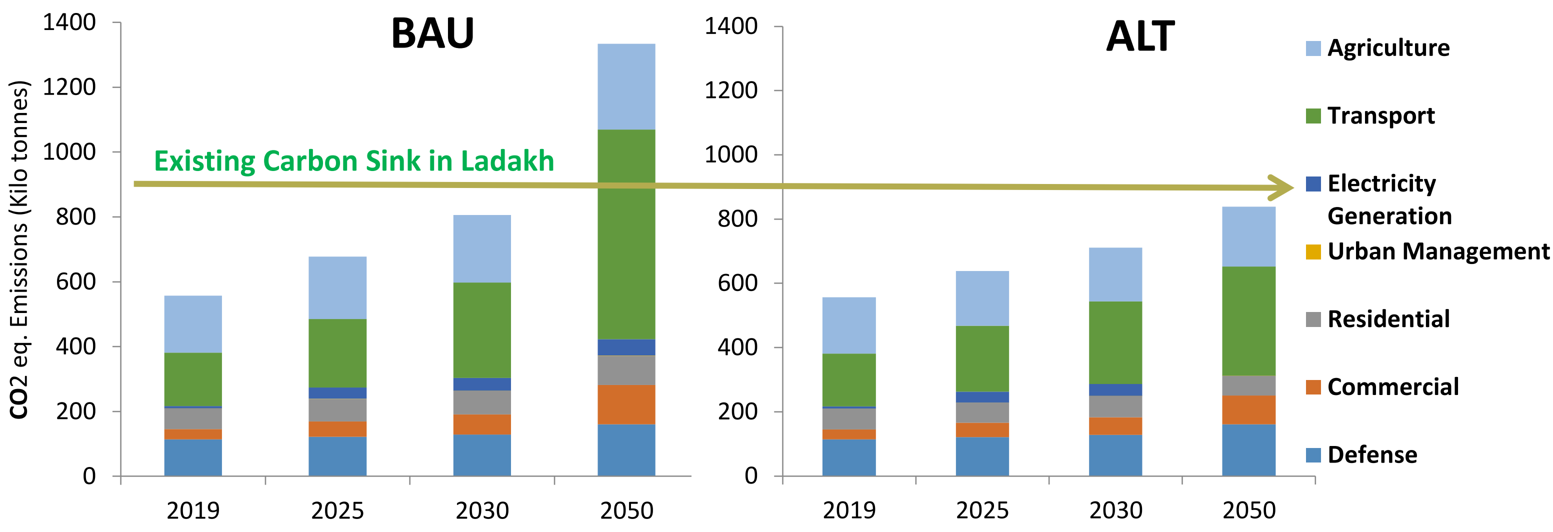


Figure 23: Aggregate GHG emissions

Chapter 5: Strategies for an integrated Carbon Neutral Roadmap for Ladakh

The carbon emission inventory assessment reveals that Ladakh has been able to maintain carbon negative and possibly will remain negative even in the near future. However, rising economic activities buttressed by increased flow of tourists from India and outside, the status quo can be challenged and situation may turn challenging with severe consequences..

The good news is that Ladakh has the potential to become India's most important ecosystem service provider if managed sustainably. Not only can it benefit the territory itself but also the entire country. The UT needs to focus on harnessing its environment to provide economic benefits while preserving it for future generation. The term ecosystem service has an expanded orbit that includes wildlife-based tourism, flow of rivers, renewable energy with huge potential for carbon mitigation and carbon storage in vast rangelands. Ladakh has significant opportunities and possibilities to leverage ecosystem services and create a carbon neutral UT.

Opportunities exist across various thematic areas that have the potential to bring benefit in reducing emission and ecological footprint in various sectors. All the measures are however intrinsically linked to sustainable development, as they help in reducing risking to lives and livelihoods and increase the resilience of communities from potential dangers of climate change. Mitigation and adaptation should go hand in hand, as some adaptation measures can contribute to reducing GHG emissions. A thematic approach has been adopted in proposing selected mitigation and adaptation strategies that will cut across various sectors and help build better resilience to communities in the UT of Ladakh.

The thematic areas of opportunities include -

- *Hydrogen as a resource for supporting energy transition*
- *Climate resilient sustainable agriculture practices*
- *Steering towards sustainable urban development services*
- *Greening transport sector in Ladakh*
- *Harnessing renewables for climate friendly electricity sector*
- *Adoption of Sustainable Tourism practices*

The following sections provide a detailed analysis and strategies for certain thematic areas that would have cross sectoral impacts at economic, social, policy and environmental level. Each thematic area discusses the potential and possibilities for exploring key strategies, possible mechanisms and means to implement along with policy and institutional support that they may require.

5.1 Hydrogen as a resource for supporting energy transition

Hydrogen has an essential role in sustaining a climate friendly future for Ladakh. Globally countries are increasingly adopting Hydrogen as a sustainable fuel options and are currently getting political and economic interest. At least 24 countries have already drafted policies or are setting up strategies for the hydrogen economy.

Interestingly, the conventional process of hydrogen production has been through the steam reforming process from natural gas. Ammonia can also be a promising source because of its relatively low cost, high energy density, and ease of liquefaction. The hydrogen is commercially cheap (US$2/kg) and is often called Grey hydrogen largely because it has a fossil fuel origin. This accounts for roughly 95% of the hydrogen produced in the world today. Most hydrogen in India is produced through reforming methane (CH4), resulting in significant carbon dioxide emissions.

However the CO_2 emitted during the production can be captured and would produce hydrogen that is often termed as 'blue' hydrogen. A climate friendly process of hydrogen production includes bio-based routes (e.g. dark or photo fermentation of organic wastes) or electrolysis of water using renewable electricity and is often termed as Green Hydrogen.

Use of Green hydrogen that is produced locally can be promising sustainable source of energy in Ladakh. Local production of Hydrogen will significantly reduce the cost of transportation. Further it can be used across various sectors including power generation, fueling transport and also space heating. Like other Indian states and UT, most of the energy requirement in Ladakh is from imported fuel and biomass. This is a challenge to preserve the pristine and ecologically sensitive local environment. Given the limits of direct electrification particularly in remote areas and the associated challenges of maintenance, green hydrogen has the potential to overcome some of these barriers as witnessed in Ladakh.

Recent years have witnessed high level price volatility with rising prices of petrol and diesel. The prices that Ladakh is paying are significantly higher than the amount paid by citizens in the Indian plains. Hence a local and cleaner source of energy is always critical to ensure decoupling emission intensity of GDP.

Biomass can be one of the sources of Hydrogen production in the region. Hydrogen can also be produced from biomass, such as crop residues, wood and dung, using pyrolysis and gasification (thermochemical) techniques. These processes produce a carbon-rich synthesis gas that can be reformed into hydrogen in the same way as natural gas or coal-based synthesis gas. The advantage of biomass over fossil fuels is that it produces no net emissions of carbon dioxide, since the carbon released into the atmosphere was previously absorbed by the plants through photosynthesis. Purely biological routes to producing hydrogen from biomass involving fermentation, anaerobic digestion and metabolic processing techniques have also come up in recent years.

5.1.1 Learning from case studies

There are growing numbers of countries that are increasingly switching to Hydrogen in end use sectors and applications and relevant for the Ladakh. Fuel cell electric buses have been on roads for more than a decade and that too in very diverse environment ranging from the hot deserts of Palm Springs, California to the winter mountain conditions of Whistler, Canada and those in Scandinavia.

Scandinavian countries have been a world leader in the installation of hydrogen refueling infrastructure. Denmark for example has one of the world's first country-wide hydrogen refueling network. Norway has numerous refueling stations and Sweden is close behind, with more likely to be built in the coming years. Furthermore, fuel cell bus refueling time is very efficient - as low as 10 minutes. This is much faster than the charging time required by 100 percent battery powered buses.

5.1.2 Recent initiatives at the National Level

India has acknowledged the importance of a transition to a hydrogen economy which is evident from the recent announcement of National Hydrogen Mission by the Union finance minister and soon after the budget the union government started preparations for holding auctions for green hydrogen. The power ministry is planning to call for green hydrogen bids in the next few months.

Even before the announcement, the National Hydrogen Mission India had witnessed few initiatives in promoting hydrogen as a sustainable source of energy. For example, the state-run enterprise NTPC had entered into an agreement with global giant Siemens in generating green hydrogen from renewable energy for its use in transportation. Pilot projects have been planned to operate hydrogen-cell electric buses and cars in Delhi and Leh. There are ongoing R&D initiatives in designing prototypes for hard/sea water electrolysis and reactors for hydrogen production through the photo-electro-chemical process. NTPC is planning to start a premium hydrogen fuel bus service on Delhi to Jaipur route.

Hydrogen can be produced in large-scale centralized plants for bulk supply or in small distributed or de-centralized. While a centralized manufacturing system may be helpful in getting scales and reducing costs, however difficult terrains like in Ladakh would pose significant challenges in transporting the gas through long distances. Hence decentralized generation facilities will be more economically viable and environmentally sustainable.

5.1.3 Strategies for Hydrogen

A transition to a hydrogen economy will require a phase wise implementation strategy that will be determined on feasible sources/feedstock, scale and potential sectors. To start with, there is a need to undertake pilot interventions and explore their feasibility, opportunities and challenges. For that matter, CSR finds from relevant public and private sector undertakings can be used for putting various demonstration projects. Further, department of science and technology in partnership with key research institutions and universities of higher learning can set up projects in selected locations in Ladakh. Further, various private sector enterprises operating in the energy space can establish public private partnership that will help in bringing more capital and global knowhow. Based on the learning and feasibility of implementation, relevant projects and end use application can be scaled up. It is proposed that a strategic roadmap for a transition to hydrogen economy is prepared in the next 6 to 8 months, which demonstrate UT administration's commitment in facilitating the transition in a time bound manner.

5.2 Climate resilient sustainable agriculture practices

The overall efficiency, resilience, adaptive capacity and mitigation potential of the production systems in Ladakh can be enhanced by an integrated approach on climate resilient sustainable agriculture practices combined with indigenous knowledge and modern organic methodologies and ensuring that institutions and incentives are in place to achieve climate-smart transitions. Different climate resilient and sustainable agricultural practices may be applied by small farmers in animal husbandry systems (e.g., biogas and composting and alternative feeding systems), in the production of crops (adaptive calendars for crops and organic farming, improved cultivation techniques, stress-tolerant cultivars, and integrated crop management), as well as in integrated agricultural systems (agro-forestry, soil, and water conservation).

The outcomes of adopting such climate resilient sustainable agricultural practices are improved access and utilization of technology, increased use of resources conservation technologies, an increased adaptation of crops and livestock to climatic stress and long-term higher productivity and farm incomes under climate variabilities.

5.2.1 Existing challenges for transitioning to climate resilient sustainable agriculture

Agriculture in Ladakh is challenged by **low soil fertility, poor infrastructure, small landholding size**, and the mountainous terrain, all of which make the activity labour intensive.

Agriculture with harvesting glacier has come-up as a small-scale farming system. **Delayed snowmelt** and **winters with less snow lead to minimal water availability** during the sowing period in April/May (Labbal, 2000). A study indicated that villagers faced insufficient water for irrigation on account of less snowfall during winters (Yangchan, et al., 2019).

There is **limited awareness among farmers** regarding interventions including integrated soil health, nutrient management, and agronomic practices to achieve good quality crop and livestock produce.

Given the potential of organic farming, the regions availability of required quantity of organic manures for practicing organic farming is a limitation. Further **availability of human waste for use as organic manure** has become an issue due to shift from traditional dry toilet to Western toilet.

Deficiency of fodder is a major constraint for livestock production systems in cold arid regions of Ladakh. Shortage of alfalfa and receding area of cereal crops are the main bottleneck for livestock production. Further, the effect of grazing on the carbon balance is poorly understood, but given the high livestock numbers, it can play a significant role in the carbon balance.

The greatest threat to forests is the **land-use change and deforestation**. It is not clear how much of each land category is suitable for afforestation for carbon sink creation.

5.2.2 Case studies

5.2.2.1 Sikkim Organic Mission

The state of Sikkim in India presents a model in the world on organic farming. Sikkim voluntarily decided to go organic in 2003 by an official resolution and is the only state of India to convert all of its farmland as certified organic. For its noteworthy achievement, it was recognized with the Future Policy Gold Award 2018, awarded by the World Future Council in partnership with the FAO and IFOAM – Organics International. Sikkim's State Policy on Organic Farming (2004) and Sikkim Organic Mission were launched in 2010 to implement the programmes and policies of organic farming in a mission mode. A series of measures were being undertaken towards this. From 2003, subsidy on chemical fertilizers and pesticides were reduced and completely banned in 2014. Necessary infrastructure was established to facilitate transitioning to organic such as, seed & soil testing laboratories; mobile soil testing vans, biofertilizer production unit, ginger processing unit, tissue culture lab, automated Green house for planting material production, rural and vermicompost units for on farm manure production. Socioeconomic aspects such as consumption and market expansion, cultural aspects as well as health, education, rural development and sustainable tourism were taken into consideration. The implementation of policy on organic farming was successful due to the fact that it combines mandatory requirements, such as gradually banning chemical fertilizers and pesticides, with support and incentives, thus providing sustainable alternatives.

5.2.2.2 Karez- Traditional irrigation systems

A good practice of a traditional managed irrigation system that minimizes evaporation losses is Karez. Karez is a traditionally managed irrigation system prevalent in Afghanistan, highland Balochistan and Turpan region of western China whereby shallow underground tunnels transport groundwater by gravity to agriculture fields downstream. The karez is constructed by tunneling into the base of a mountainous area, following a water-bearing formation and the tunnel is roughly horizontal with a slope to allow the groundwater to flow by gravity. This system minimizes evaporation losses since most of the water transportation takes place underground and thereby sustainable in arid environment. The amount of water for irrigation is dependent upon the underground water table and precipitation which take place during the winters as snow (Cui et al., 2012) (Himat & Dogan, 2017) (Scot et al., 2019).

5.2.2.3 Integrated landscape approach for assessment of natural resources in Kyrgyzstan

The Government of Kyrgyzstan in 2007, with the support of FAO, adopted an integrated landscape approach to assess the country's forest and tree resources and strengthen the national monitoring capacity. The government designed and developed a comprehensive National Forest Inventory (NFI) in 2010, first inventory of its kind to be carried out in the Central Asia region, of all forest types and land properties to mitigate climate change impacts through Sustainable Forest Management. National capacity building of staff from the Department of Forest, Hunting and Ground Inventory (DFHGI) were undertaken and training on national forest management assessments, including analysing, managing and disseminating collected data were provided. A national forest vegetation and landuse classification system for remote-sensing surveys was developed. Further, a database to store and manage information from the forest and land assessments was designed by the joint effort of FAO and the DFHGI. A range of stakeholders related to forest and tree resource management, forest services, scientists, civil society, line ministries and international partners were brought together in order for adopting a sector-integrated approach to assess the country's forestry resources and their multiple functions (Chyngojoev et al., 2010).

5.2.3 Ways of implementation

Given the limitations, of agricultural strategies and practices towards reducing greenhouse gas emissions or increasing soil carbon sequestration, both in terms of their climate benefits and overall socio-economic benefits, it is important, for optimal environmental, societal, and climate outcomes, to prioritize climate-friendly practices that reinforce carbon farming systems (suite of climate-friendly practices and strategies including grazing and animal husbandry). **Funding for research into agro-ecology, agro-forestry** which has a much greater potential to positively impact the climate than conventional systems **need to be prioritized.**

The **use of composted manures in agricultural soils should be encouraged** as it is a food source for the soil microbes, the manures and the microbes interactions will increase the soil organic matter content making the soil more fertile and more sustainable for crop production. Burning of organic materials should be regulated and these could be potential source of manure.

In order to minimise the harmful effects of intensive use of chemical fertilizers and pesticides, a holistic view of soil fertility based on retaining its natural nutrients is required. For this, a crop management system that promotes the use of organic manures, bio-fertilizers and bio-pesticides and the judicious use of agro-chemicals should be adopted. To improve the sustainability and performance of agriculture, **a greater policy focus on bio-inputs** will be important. Proper infrastructure for quality bio-inputs and its access to the farming community can be enhanced by way of suitable incentive mechanisms and standard setting. The use of bio-fertilizers, which can increase the carbon sequestered in the soil and therefore the soil organic matter, as a substitute for chemical fertilizers needs to be explored. Bio-fertilizers are however sensitive to extreme climatic conditions than agricultural chemicals and are relatively difficult to handle, as a result their adoption will need massive awareness program. In addition, their shelf life is short, therefore demanding efficient and timely delivery mechanism. This would enhance circularity through better utilization of organic/compostable waste while increasing agricultural productivity and timely availability of the inputs. There has been a considerable research and development undertaken in recent years to promote sustainable agriculture in cold and dry locations. Thus a mapping is the need of the hour that can be taken to the pilot level to learn their scalability potential

Effective use of technologies like **biotechnology, information and communication technology, renewable energy technology** provides ample opportunities to overcome the prevailing technology fatigue. Digital agriculture through use of ICT and emerging technologies could play an important role in helping to adopt various climate-smart interventions. The promotion of energy-efficient solar pumps for irrigation accompanied by micro-irrigation facilities reduce the requirement for water pumping, and consequently of the electricity needed to pump it, thus reducing the cost of the expensive solar panels while the excess electricity is procured by the electricity distribution company. The purchase of the excess electricity provides a revenue stream for farmer-entrepreneurs, which enables them to invest in the solar panels, energy efficient pump and micro-irrigation facilities, as well as minimize fertilizer and water use.

Cost-effective technologies suited to small-holder farming, strengthening the capacity of soil testing infrastructure, incentive mechanisms for adoption of efficient pump-sets and their effective usage need to be devised.

Innovative way to cluster organic farms to produce high value crops **and adoption of low cost passive solar greenhouse need to be devised.** The cluster approach to setting up such solar green houses will aid in providing nutritional security of local inhabitants and meet the growing demand from tourism and armed forces. Accordingly, incentives to farmers groups to adopt improvised greenhouses such as DIHAR Greenhouse need to be provided to support the value chain

Climate change and its impacts need to be understood and appreciated by relevant stakeholders at the local level, especially at the level of local self-governments. The institutions at the local level can leverage funds from various schemes such as MNREGA and utilize them for natural resource management, agro-forestry, and other relevant activities that will help build resilience to climate change as well as increase farm productivity and farm incomes.

A comprehensive forestry inventory and land use planning can be implemented in the case of Ladakh. Forest carbon accounting may be undertaken by collating data on forest inventories, woody biomass assessments, agricultural surveys, land registry information and scientific research. Subsequently, reforestation, afforestation, increasing carbon density of existing forests, reducing emissions from deforestation and degradation (depending on the current forest sink, competition with land-use and watershed protection) need to be undertaken. For this inventory methods have evolved and new tools are currently available, such as the FAO-Google Collect Earth tool. Tool for landscape level planning for different land uses such as ROAM (Restoration Opportunities Assessment Methodology) developed by ICN and WRI can be adapted towards climate-resilient sustainable agricultural practices & benefits. Capacity building of officials in applying such tools need to undertaken.

5.3 Steering towards sustainable urban development services

Rapid urbanization in the UT of Ladakh has increasingly led to many ecological, political, social, and economic transformations. Urbanization in the mountainous regions is not only limited to high population growth rate, rural to urban migration or the increasing influx of tourists but is also accompanied by issues of limited availability of suitable space for construction, waste management and also water scarcity in case of Ladakh. The urbanization in mountainous regions also leads to air and water pollution issues at a larger scale which are coupled with expanding tourism sector.

To ensure a sustainable urban development of the UT of Ladakh, it is important that a proper water management system as well as waste management system is established in the region. The region faces multiple challenges in terms of water management; however according to primary sources it can be said that the UT is not facing any water crisis but a gross water management crisis. The increasing movement of people, tourists, migrant laborers and even defense has led to significant impact on water demand. The major challenges the region is facing are an erratic water supply system, increasing water demand due to rising tourism and inhabitation and groundwater pollution due to the absence of a proper sewage system. Both the districts' water management system is facing infrastructural, technological, financial, regulatory and human resource issues.

The overall water management system is facing issues around infrastructure, technology, manpower and even finance which is causing inefficiencies in the overall system. The piped water system has not been completed yet and is under construction, so is the waste water treatment facility in Leh. Currently the wastewater mostly flows into septic tanks and soak pits and into the ground. The rising demand for water has also led to large scale extraction of groundwater sources for which approximate 1200-1700 private borewells are being used in Leh city only. Therefore, establishment of an efficient water supply system is required with water meters that can regularly monitor the system for any water leakages. Also, the use of diesel pumps needs to be replaced by electric/solar pumps.

The region due to its rising tourism sector has also seen a rise in the number of buildings and a change in their type. Earlier earth and stone were the most common building materials that were used, now they have been replaced by concrete blocks that have a lot of thermal requirements. Therefore, the uptake of energy efficient buildings is required in the region that can not only cater to the needs of the rising tourism sector but also to the fuel demands.

The tourism sector has also led to problems of solid waste management. Though the facility of door-to-door collection of solid waste is provided in the region, there is no waste segregation at source. Also, no effort is being undertaken to recover necessary materials (metals, glass, ceramics, plastics) from various types of waste (construction and demolition, municipal solid waste) due to lack of relevant infrastructure in the region. Therefore

5.3.1 Case studies

From 'Water Scarce' to 'Water Surplus' Shimla

In 2018, Shimla faced the worst of its water crisis when the city did not get a drop of water for almost eight days. This was like a wake-up call for all the urban planners, citizens and the environmentalists to practice water conservation and build an efficient water system in the town. This started with the establishment of a professionally-managed, autonomous utility to manage water and sewerage services for the city, the Shimla JalPrabandhan Nigam Ltd (SJPNL). The several quick steps taken by the body were to improve water quantity and quality, including replacing leaking bulk-water pipes, upgrading old pumps that raise water from river valleys thousands of feet below the city, expanding the number of daily water samples taken for testing, and increasing the volume of sewage collection. In the next phase, it planned to focus on three critical areas: (i) bringing bulk water to Shimla from a new source on the Sutlej River; (ii) providing continuous (24x7) water supply and improved sewage management for Shimla City and; (iii) expanding sewage services for the peri-urban areas of the growing city.

Along with the improvements in infrastructure, the SJPNL switched to volumetric water tariffs for the city, with subsidies targeted at low-income households. To ensure that the poorest households are not hit by the hike in tariff, SJPNL kept the price for the first 'lifeline' slab of water consumption at an affordable Rs 100 for 7 kilo litres. It is also allowed poorer households to share a water connection, and to pay for the connection through installments. Other than these institutional changes, conservation drives were carried out that involved female volunteers, known as 'JalSakhis' and other stakeholders, especially hoteliers to educate consumers about the changes in water delivery and helping them conserve water.

All these collective efforts of the government and the citizens led to Shimla being a water surplus region in just one year and the water availability increased from 38 MLD to 49-51 MLD.

Passive Solar Houses

The passive solar houses have architecture that are heated naturally without emitting any carbon emissions or burning any fuel or use electric heating. Passive solar design absorbs heat from the sun and then stores it as long as possible. It does not use circulating water pipes, air blowers, or moving parts. With only passive solar heating, the SECMOL Campus and the HIAL campus in Leh stand quite heated even when the outside temperatures drop down to -10 degrees celsuis. The main features that keep the buildings warm are:

- South facing windows, as the sun moves low in the southern sky in winter.
- Greenhouses are attached the south side for winter.
- Greenhouses are removed in springtime to prevent overheating.
- Skylights are covered with glass or clear plastic to keep warm air indoors.
- Thick earthen walls and floors to store collected heat (thermal mass).
- Insulation in the roof, outer walls, and in some places under the floor.
- Natural lighting so electricity is not needed for light in the daytime.

Integrated planning and collective implementation

Sweden focuses on developing integrated planning and management that has increased stakeholder involvement. The Hammarby, a district in Stockholm focuses on a ecocycle. This ecocycle focuses on "energy, waste, water, and sewerage for housing, offices, and other commercial structures. Development plans were undertaken jointly by three agencies the

Stockholm Water Company, the energy company Fortum, and the Stockholm Waste Management Administration. The management of the project was centralized and was led by a team comprising representatives from city departments including planning, roads and real estate, water and sewerage, and waste and energy. The focus of the model is to create a cyclic system that focuses on resource optimization and minimizing wastage.

One of the key focus areas of the model is to streamline infrastructure and urban service systems which enable to envision sustainability objectives. The building materials utilized in the district should be environment friendly and avoid usage of hazardous materials including copper and zinc.

As Ladakh is still to adopt an integrated management plan for its cities and town. The size of the cities and towns in the UT district provide an opportunity to develop and explore tailor made management plans that focus on sustainability

Major focus has been given to waste treatment - The district ensures that storm and rain water is separated from sewerage systems to improve quality of waste water and sludge and reduce pressure on waste water treatment plants. HammarbySjöstad has its own wastewater treatment plant built to test new technology and at several processes are tested simultaneously to identify appropriate technology to purify water.

Organic waste and sludge from waste water plant is utilized to produce biogas. The waste water from one household provides enough biogas to be utilized by the households cooking needs. Considerable part of the biogas is also utilized in transportation sector as fuel in eco-friendly cars and buses.

Waste: Waste in the district is segregated and deposited in different refuse chutes that are installed in building or built near them. The refuse chutes are connected to underground vacuum powered pipes that transfer the waste to a central collection station. The station has an advanced control system that sends waste to large containers for each category. This system reduces the need for collection vehicles to make door to door to visits.

District heating and cooling: The waste water and domestic waste systems are intrinsically linked to the heating, cooling and power generation in the district/ Treated wastewater and domestic waste become sources. Domestic waste is utilised to generate power and heat- a necessary aspect for a country that experiences extreme cold temperatures. The heat plant in the district enables district heating through the use of waste water from treatment plant. Additionally, cooled by heat pumps, the treated and cooled wastewater is also suitable to be utilised in district cooling network.

Solar Energy: Majority of the rooftops are covered by solar. Due to extreme winters, the need for hot water is significantly higher and the Solar energy provides adequate energy for heating water for all buildings.

5.3.2 Ways of Implementation

In order to transition from the present state to a sustainable urban management to reduce the emissions from the sector, it is imperative to implement strategies in sectors pertaining to water management, construction and solid waste management.

Structural Recommendations

- In order to reduce water losses, water meters need to be installed in the service reservoirs to monitor the inflow and outflow of water from the reservoir.
- Piped connections to households need to be provided by the municipal authorities in Ladakh. This will ensure water continuity and reduce dependency on groundwater.
- To promote sustainable habitats, green certification systems might be introduced.
- To promote sustainable waste management practices in Ladakh, GIS mapping for identifying appropriate landfill sites needs to be conducted.

Financial Incentives

- Water tariffs for piped water connection can be marginally raised to maintain the cost of operations. The other alternative is to introduce a differential pricing strategy. Currently, the government charges an annual fixed tariff from the connected households and commercial units but the total billing from the registered connections is far less than the cost of operating the system.
- Wherever necessary fines need to imposed for unlawful extraction of groundwater by commercial establishments.
- In order to regulate water use in commercial establishments, taxes may be levied after a permissible limit by relevant authorities.
- Subsidies might be provided for new constructions which have been certified by green rating agencies such as GRIHA.
- Tax concessions might also be provided to establishments which have installed water metering systems.

Policy Measures

- There is an immediate need for an overarching policy to promote sustainable water use management in Ladakh. This will not only form the backbone of a resilient water management system but will also regulate groundwater extraction.

- Policies may also be framed to promote use of sustainable building materials for construction purposes.

In order to promote sustainable waste management practices in Ladakh, the Solid waste management rules 2016 need to be operationalised through appropriate state agencies.

5.4 Greening transport sector in Ladakh

Transitioning the land transport sector towards near zero emissions will require strategic policies and investments that will catalyse and incentivize the shift to clean transit without unduly burdening individuals, businesses, or government resources. Few mitigation options which Ladakh needs to consider for low emissions development are adoption of EVs, fuel cells and biofuels from technology perspective, shifting and developing public transport systems and undertaking policy transformations in vehicle renewal policy, tackling congestion and revising tariffs for vehicles entering into UT .these actions can be planned and piloted in upcoming years. On ground implementation could be envisaged upon the completion of successful trials.

5.4.1 Promoting Adoption of EVs

Electricity is proving to be comparatively easy to decarbonize in Ladakh than other parts of the country, and thus EV emerges as the most effective way to reduce emissions from transport sector substantially. The UT conducted feasibility demonstrations of EVs in extreme winter conditions and explore hybrid electric vehicles (HEVs) which can run on electricity in summers while diesel can be used in winters when vehicle kilometers travelled are much lesser than in summers. This will reduce the overall emissions, but the promotion of EVs and HEVs will require overcoming the higher costs to consumer and businesses. The incremental investment would be recovered with lower operating costs, which need to be awarded to the vehicle owners' effectively. In addition to the financial assistance provided by centre under FAME II scheme, UT should announce additional top-up subsidy for faster adoption. Expanding the commitment to cleaner fuels, UT should replace the public transport vehicular fleet and public services vehicles with HEVs in near future and complete EVs gradually.

EV in Colder regions

One key concern in adoption of EV vehicles is the reservation on its functioning during sever cold temperature. The Case of Norway has been specifically highlighted as the country experiences extreme cold with temperatures declining to -20 degrees and even lower in many other areas.

New EV models are being tested to withstand extreme temperatures with significant reduction in loss of range of the vehicle. For instance, the Hyundai Kona loses 9% range in extreme cold temperature and many other models have preheating mechanisms installed in the vehicle to battle extreme climates.

Multiple usages of batteries: Particularly for Ladakh, increasing renewable energy integration would require large energy storage systems in place due to unpredictability of solar and wind. The energy stored in vehicles can thus serve as the source when demand rises in the grid. The bidirectional vehicle to grid (V2G) capabilities can thus improve the participation of RE sources and reduce the overall system costs. The effective grid integration system will be required which can be first demonstrated at bus depots and government offices.

5.4.2 Fuel cells and Biofuels

Hydrogen and fuel cells offer promising choice for transitioning to carbon neutral territory. The suitability of hydrogen as fuel can vary between different transport modes, which can really prove to be effective for truck movement that are part of army contingents. With army constituting the major share of vehicular movement, hydrogen as a fuel for defense transport and other requirements has plenty of scope to reducing the regions emissions. Similar to electricity hydrogen can be used as fuel in many ways spanning the whole energy systems.

While for demand pertaining to passenger vehicles, usage of biofuels needs to be encouraged. Biofuel production has been demonstrated commercially from many feedstocks. Used cooking oil (UCO) has lot of potential for the region to produce biodiesel which has lower infrastructural requirements. With UT having plenty of hotel facilities to cater to the increasing tourists' footfall, UCO can replace the significant share of diesel consumption. Mandatory collection of UCO from these facilities should be regulated, which can be processed at a central facility.

5.4.3 Vehicle renewal

With the significant share pre BS IV level vehicular fleet, emissions from these vehicles remain a challenge. This older fleet also operates inefficiently, which in turn contributes to emissions. The fleet modernization program can significantly reduce the environmental burden and the implementation would require establishment of a licensed dismantling unit ensuring scrapped vehicles are not restored. The UT can consider offering 50% exemption on excise duty and road tax on purchase of new vehicles. The dismantling units can provide scrappage certificate to the vehicle owners which can be eligible for these benefits.

Promoting more efficient trucks and taxis: The vehicular movement in Ladakh region is majorly from two modes of transport i.e. trucks for defense movement and taxis for tourists' movement. The efficient transit of the vehicles kilometers travelled for these modes will significantly reduce the emissions. These trucks and taxis can improve efficiency through cost effective methods like tyre upgradation, eco-driving in short term. While fleet modernization and integration of EVs or fuel cell vehicles should be the long term goal.

Improved inspection and maintenance system: The on-board diagnostics (OBD) system at the Pollution Under-control Certificate (PUC) centre needs to be established to effectively monitor the emissions from vehicles. Strict compliance needs to be ensured with the fine on the defaulters under a penal mechanism.

5.4.4 Promoting public transport

The usage of public transport in the UT is not so encouraging, which leads to the emission and traffic congestion challenges. Ladakh should aim to enhance use of public transport through ensuring last mile connectivity by the battery enhanced cycles which can also serve as the twin purpose of last mile connectivity, and mode shift which could be encouraged through "charge and earn" model in which the rider can take the bi-cycles home and can earn if park back the charged cycle. This would promote bus usage, which should also be enhanced by investments in public transport infrastructure, connectivity through all the major routes, and self-sustaining revenue model to improve bus usage operations.

Roadway pricing could be imposed which can be implemented in number of ways. These include charging tolls, cordon pricing as a charge to enter or exit a particular location. The vehicle kilometers travelled could be criteria for the pricing mechanism. The pricing approach could include a congestion charging element, higher fees at peak travel hours.

5.4.5 Tackling congestion

The peak season in the Leh city has caused the issue of traffic congestion quite frequently. In addition to encouraging the public transport, following options can be effectively promoted.

Mode shift: When the most or all of vehicles are electric, mode shift will no longer reduce emissions as the direct emissions will be zero from land transport, independent of the mode used. However, the increased number of EVs would continue to congest the road, resulting in accidents. Even after lower or no emissions at that time from EVs, promoting public transport and non-motorised transport (NMT) will still be justified as it will reduce congestion, reduce car accidents, improvement in health by cycling and walking, and reduced environmental impacts for required road infrastructure. Investment in pedestrian and NMT infrastructure will be required to provide convenient and enjoyable alternative to car travel.

For Ladakh, the introduction of cycling for tourists could also include provision of cycles for younger generation visiting the UT. Young cyclists could be rewarded with discounts or passes for specific tourist attractions, restaurants etc.

The bicycling programme in most cold countries experienced reduction in usage during extreme cold periods, but regained momentum with increase in temperatures.

Dedicated parking facility: The dedicated parking lots at the identified hot spots areas are required to tackle traffic congestion. A multi-level and multi-purpose smart parking facility should be designed which can act as the charging station for EVs in future, and can operate on sharing basis with businesses. It can act as a focal point for promoting "park and cycle" model.

5.4.6 Bike Sharing Systems- Good Practices

Most bike sharing systems across the globe are part of a larger sustainable mobility plan. Promoting Cycling as a mode of transport requires consistent efforts and change in the city or region's transportation culture. For Ladakh, during peak tourist seasons, bike sharing systems would provide an environment friendly mechanism to reduce heavy traffic in tourist destinations. The key advantage of bicycles is their potential for utilization in any type of physiographic zone. The procurement of the appropriate bicycle suitable for short hill climbs could be utilized for the Ladakh region. Certain areas such as shopping areas and heritage destinations could promote bicycling and walking as a mode of transport to create zero emission zones.

5.4.7 Infrastructure transformations- Case of Bogota, Columbia

Bogota, Columbia has one of the most successful cycling networks in the world. The cycling network that began in 2015 witnessed 635000 trips on a daily trips which increased to 800000 trips by 2018. Provision of Cycle only lanes proved beneficial and led many to adopt bicycles. The construction of bike only pathways was key in enhancing the adoption of bicycles. Planned and envisaged infrastructure additions in Bogota embedded cycling as part of city planning process.

As Ladakh has significant transit population who largely belong to low income groups, the provision of cycle at low costs would be an attractive option. Additionally, Bike sharing systems could be introduced with annual membership for permanent residents and short term smart cards for tourists and transit population.

With increasing tourism in Ladakh, the use pubic bicycle sharing system for short hauls within cities and smaller towns will reduce motorized transport and enhance emission free transportation. The bicycle sharing systems could be applied in phased manner to understand its impact and its utilization.

> Bike sharing systems could also be promoted as a major way of transportation for the defense establishments. Increase use of Bicycles between short distances and within defense areas would significantly reduce emissions from this sector.

5.5 Harnessing renewables for climate friendly electricity sector

With the established enormous potential of various RE sources and availability of non-arable land in large proportion, renewable energy based electricity generation including solar and wind based installations should be developed considering the environmental and economic benefit for the region. The large scale deployment of renewable energy in the region can unlock the economic development with job opportunities, improve energy security, improve access to energy, along with mitigation of climate change. Harnessing the renewable energy potential will easily offset the GHG emissions and will fetch the carbon credits for the region.

From the existing potential of feasible solar and wind energy generation of 40GW as per the assessments, the RE parks can be developed in identified and surveyed patches under an special area demonstration programme. Ladakh being the highest receiver of solar irradiation of about 7-7.5kWh/m2/day and with the capacity utilization factor (CUF) of about 25%, holds the key to recover the investments quickly. This will attract large investments from the private players, and an effective land lease model could be worked out for the successful implementation. Prior to this, a capable evacuation system should be ensured, for which the transmission link is underway routing via Manali in Himachal Pradesh and further to Kaithal in Haryana. However to make electricity sector completely independent of fossil sources, phasing out of diesel gen-sets is required.

The energy storage is essential and will help giving the extended supply beyond 8 hours in non-grid areas, and it will strengthen the flexibility of the grid to reduce usage of diesel gen-sets in winters when hydel energy availability reduces. This will require end-of-life regulations for the disposal of batteries, with the establishment of recycling facility of the chemically polluting batteries.

5.5.1 Challenges for exploiting RE potential

The chapter 4 projected the necessary capacity additions in a more aggressive alternate scenario. However, there are exists key challenges concerning the transition to clean electricity sector including;

Policy and regulatory obstacles:

- A comprehensive policy statement is absent for the renewable energy sector to promote growth of emerging RE technologies. An integrated plan to completely make electricity sector in UT fossil independent is not available.
- The regulatory framework needs to effectively devise the maintenance of RE projects as results in efficient operations. Particularly for decentralized solar micro-grid operators this emerges as a critical challenge. The penalty mechanisms are needed to be instigated for any non-compliance issue.
- The transparent model between private and public partnership (PPP) is not available. The land lease model for development of RE projects is still unclear and needs to be prepared in coordination with private stakeholders.

Institutional Obstacles:

- The poor inter-institutional coordination is the major restraining force for the RE development, as the lack of cooperation results in delay in implementation of policies that will affect the investor's interest in future.
- The workforce in institutes, agencies, and ministries is insufficient to drive the large RE deployment.
- Collaboration with research centres is not significant for development of renewable infrastructure in the region.

Financial Obstacles:

- The upfront capital cost of RE projects is very high compared to other parts of the country, which leads to initial burden. The moneylenders consider it risky to provide funding.
- Lucrative fiscal mechanisms that can attract investments are not in place. The subsidy for rooftop solar or the tax benefits for the large project developers are explicitly important to boost investments.

Technological Obstacles:

- Strengthen and efficient Grid: The aggregate technical & commercial losses (AT&C) stands around 45% that depicts the poor transmission and collection efficiency. However, the existing transmission network can only facilitate the 300MW of power evacuation. The incapability of power evacuation has been the barrier in large scale projects development.
- Non-electric energy applications: The dependency of domestic sector is largely on non-electric energy appliance that fails to create the enough demand of electricity. This also results in significant emissions.

*Despite the large existing potential for renewable energy systems, the gap exists between the actual and desired actions. The "5-**in**" model (UNECE) can be conceptualised for meeting the gap*

- ***in**vestment*
- ***in**formation*
- ***in**novation*
- ***in**centives*
- ***in**itiatives*

5.5.2 Way-How of Implementation

The renewable energy deployment will be critical for the low emission development in the region for which strong government support is required to create economic opportunity for investors and required to simultaneously design policies, programs, and create a liberal environment to attract investments. The following options will help push the region an inch closer to carbon neutrality:

Promoting Investments

The key strategies to promote investments in renewable energy sector will include:

- Providing open, transparent and dependable conditions for RE players, with the provision of ease of doing business, flexible labor markets, and safeguard of intellectual property rights.
- Establish an investment promotion agency (IPA) that can target suitable and potential investors preferably domestic. This agency can also be formed for other areas of interventions including transport, etc. This IPA will need to present the required infrastructure, skilled human resources to attract the investors. The agency can also enact as feedback system for the region by learning the requirements of investors.
- Establishing the infrastructure required for the potential investor, including adequate transport facilities (air, rail, and road), sufficient and steady supply of energy, skilled workforce, facilities for training programs designed in collaboration with investors.
- The support mechanism such as Power Purchase Agreements (PPA) and Feed-in-Tariff (FiT) will play an influential role in restricting uncertainities of developers. Reassurance of future power costs for developers is secured by PPA signing with utility. While with FiT in place, developers qualified for projects can anticipate the returns for longer intervals.

Policy Measures

- The LREDA should prepare the comprehensive action plan and policy for renewable energy with the fixed time frame and execution plan. The policy can be prepared in consultation with PDD.
- There should be strong local level approval system from municipality and other departments for approval of RE projects.
- Given the challenges in maintenances of services provided by the operators, it should be made explicit in the tender itself for the service coverage for entire period of operations and maintenance relating to major technical requirements while adequate training of the locals should be mandated by the service provider for sustained operations of solar micro-grids.
- The policy maker should look at developing the Renewable Energy Certificate (REC) market. The REC policy ecosystem can promote the funding mechanism.
- The government should establish the effective indigenous utility in the region which is currently being operated by J&K PDD. The government should further look at addressing the issues of utility financials, and problems pertaining to transmission and evacuation.
- Most of the other states have defined Renewable Purchase Obligations (RPOs) targets for utilities. Currently, the region is majorly supplied through renewable

hydro power and should aim to become 100% RE based economy by 2030 by eliminating DG sets.

- The policy on energy storage should be developed with the identification of cumulative storage requirements, total market size, demonstrated chemistries, and supply of batteries.
- The policy regarding off grid and decentralized solar photovoltaic application program is required for the far flung areas which are still not connected through centralize grid network. The program should intend to solarize all decentralized villages with stand-alone micro grids and the deployment of solar lanterns, solar streetlights, and solar pumps.

Transmission Requirements

- The developers are worried that transmission facilities are not in place to evacuate the large scale RE based power generation. Existing lines are already carrying the full load. The RE deployment can be devised in coordination with Power Grid Corporation of India (PGCIL) and CEA, making sure enough evacuation facilities exists.
- To reduce losses grid strengthening will be required to transmit electricity at higher voltages, and other operating techniques to reduce losses like reactive power support, low resistance cables can be adopted. Further for exporting electricity from upcoming large scale solar project would require an evacuation program through multiple points.
- Numerous sub stations along with transmission lines will be required to be developed. The fund requirements should be fulfilled and process needs to be expedited as halting the RE deployment.

Financing RE sector

- The UT government should provide enough budget allocations for RE sector. With the special focus on R&D, the surplus fund for R&D should be allocated along with the provision of monitoring the budget allocation.
- The benefits in terms of lower interest rate to housing loans if building is constructed with rooftop solar. Further, income tax rebates can be provided.

5.6 Adoption of Sustainable Tourism practices

Sustainable tourism ensures the right balance between environmental, economic and socio-cultural aspects of tourism development and also ensures the ecological balance. Sustainable tourism also attempts to minimize the impacts on the environment and local culture so that it will be available for future generations, while contributing to generate income, employment, and the conservation of local ecosystems. Thus, for a region like Ladakh, sustainable tourism is an important aspect because of the growing impacts of tourism on the sensitive ecology of the region. Sustainable practices if followed by the tourists will maximize the positive contributions to the ecology and biodiversity of the region as well as help achieve economic gains and poverty reduction, thus moving towards sustainable development.

5.6.1 Pertinent challenges in Tourism sector

The primary challenges emanate from the environmental degradation caused due to anthropogenic activities necessarily resulting from inefficient management, lack of infrastructural facilities and certain pervasive behavioral traits of tourists. Figure 24 illustrates the overall purview of challenges in the sector from the point of view of carbon neutrality.

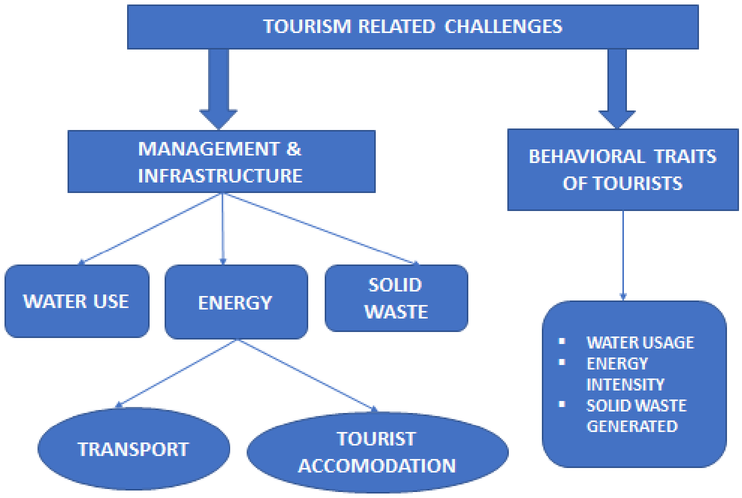


Figure 24: Framework for Tourism induced Challenges

5.6.2 Strategies and Recommendations

Tourism is one of the highest revenue generators for the Union Territory and would remain so in the near future. It has significantly boosted the local economy for the past few decades, however, there is a need to preserve the environment, culture and the local practices – which are the main attractions for the tourists. There is need to deploy a spirited combination of strategies that could address the immediate anthropogenic impacts and prevent further damage to environment and local way of life. Hence it is envisaged that the strategies and interventions need to be undertaken at the policy, institutions and at stakeholder (hotels, transport and tourists) levels.

There is need to accelerate the drafting and adoption of the Eco-tourism policy and establish stringent rules for all stakeholders. The administration needs to interlink, merge and implement policies in other sectors such as energy and water in conjunction to the future demand that would emanate from the tourism sector. Some of the recommendations at the policy and institutional levels are highlighted below:

5.6.2.1 Policy Level Interventions

- **Encouraging homestays and guesthouses as a primary accommodation –** Homestays and guesthouses that follow traditional practices such as dry toilets, promote local cuisine and provide eco-friendly services including no use of plastics, utilise solar for energy and water heating to the maximum extent possible and use energy efficient appliances should be encouraged by providing incentives such as tax breaks.

- **Incentivising non-motorised and electric transport-** Ladakh has several tour operators who offer two wheelers and three wheelers for hire/rent. Such operators should be encouraged to provide bi-cycles and e-bicycles for travelling in around Leh. The purchase of such bicycles needs to be subsidised by the UT for faster adoption and use.

- **Regularise the process of obtaining permits for groundwater extraction –** The most complex challenge for the district of Leh is accelerated use of water specifically due to increased tourism in the region during summers. A stringent policy to reduce (in the short term) and eliminate (mid-term) the use of water pumps in accommodations is necessary to preserve water. Metering tools for piped and pumped water would enhance monitoring and aid in pricing of water especially in the tourist sector as higher price on water usage would deter haphazard water wastage.

- **Regulating tourist movements in fragile ecological zones –**Tourists from within India and across the globe arrive in Ladakh to view its natural landscapes and experience its pristine environment, however this influx of tourists is concentrated in few zones leading to severe environmental degradation of such areas, for instance Pangong lake. A thorough evaluation of each area in the UT needs to be undertaken and tourists could be encouraged to visit areas that are least explored to reduce the stress on existing resources. Tourist inflow in certain frequently visited and environmentally impacted areas could be controlled by levying entry fees as one o fthe strategies. In extreme circumstances, closure can also be an option. The closure of Hemis National park to tourists[21] is a good example on ways to preserve its ecology.

- **Creation of zero emission zones –** Vehicular movement in fragile ecological zones need to be restricted especially in areas that have significant glacial formation to reduce emissions. Cycling and trekking with cap on tourist visits per day should be explored.

[21] Interview with officials at Forest Department, UT of Ladakh

- **Moving from minimal to zero wet waste -** The local/traditional practice of generating minimal to no waste especially for wet waste needs to be emphasized in the commercial sector. Promotion of composting wet waste for horticulture or collection of wet waste for community level composting could be some of the potential options.

5.6.2.2 Institutional Interventions

- **At the UT Level**
  - **Ensuring piped water connections –** the provision of piped water connections to hotels especially in Leh town is anticipated to reduce the stress on existing groundwater resources.
  - **Solid Waste Management –** Decentralised waste collection needs to be enhanced, with particular emphasis on promoting waste segregation at the collection level to ensure sustainable practices and also to enhance the scope of waste recycling (eg. plastics and glass). This will require creation and upgradation of necessary infrastructure such as deployment of waste collection vehicles, segregation of the waste at source, recovery of essential materials, recycling of waste and finally safe disposal of unrecyclable waste. Although a centralised waste treatment plant is under construction in the Leh town, decentralised waste management practices are advocated to reduce the collection time and ensure efficiency.
  - **Promoting Adventure tourism –** Concerted effort should be undertaken to enhance adventure tourism that promotes zero emission recreational activities such as trekking, mountain biking etc. This would allow tourists to understand the ecological value of Ladakh and reduce tourism based carbon footprint.
- **Tourist Accommodations**
  - **Mandatory Installation of solar panels and water meters-** The installation of solar water heaters has been on the rise in Ladakh, however the promotion of rooftop solar for electricity generation should be explored specifically for tourist accommodations. Appropriate incentives and subsidies could be provided to promote its adoption for energy generation. Metering of water is essential to ensure that the long-term sustainability of tourism in Ladakh facing water stress during peaks in summer.
  - **Encouraging dry toilets in tourist accommodation-** Dry toilets are an essential part of **traditional** culture of Ladakh and its functionality needs to be disseminated among tourists for easier adoption. The use of dry toilets reduces water usage, provides compost for agriculture and reduces the need for septic tanks. Promoting the building and use of dry toilets in all tourist

accommodations needs to be adopted. Mandatory construction of septic tanks is necessary to eliminate ground water contamination.[22]

- **Incentivising tourists to adopt sustainable practices –** Certain pricing mechanisms such as provision of discounts, redeemable credit points and pay as you use etc. can be introduced to encourage tourists to adhere to environmentally friendly practices.

- **Tour operators and Taxi services**

  - **Creating value by promoting sustainability –** Tour operators should emphasize and promote **homestays** and local culture. Offers to arrange stay with a local family should be promoted to introduce the culture and reduce focus on luxury based tourism.

  - **Promoting regular audits and verifications –** Tour operators, taxi services should be regular audited **to** ensure sustainable practices are being promoted. A case in instance, is the Trinidad and Tobago Tourism Industry certification Scheme.

  - **Organizing clean up and sustainability campaigns during peak seasons-** According to interviews **conducted** with Department of Tourism in UT of Ladakh, "At end of the season cleanliness drive is organized to collect all the garbage to take it for proper disposal"[23] especially in areas that witness adventure tourism. Such initiatives should be undertaken during peak seasons enabling tourists to experience the challenges emanating from tourism and also participate in these drives.

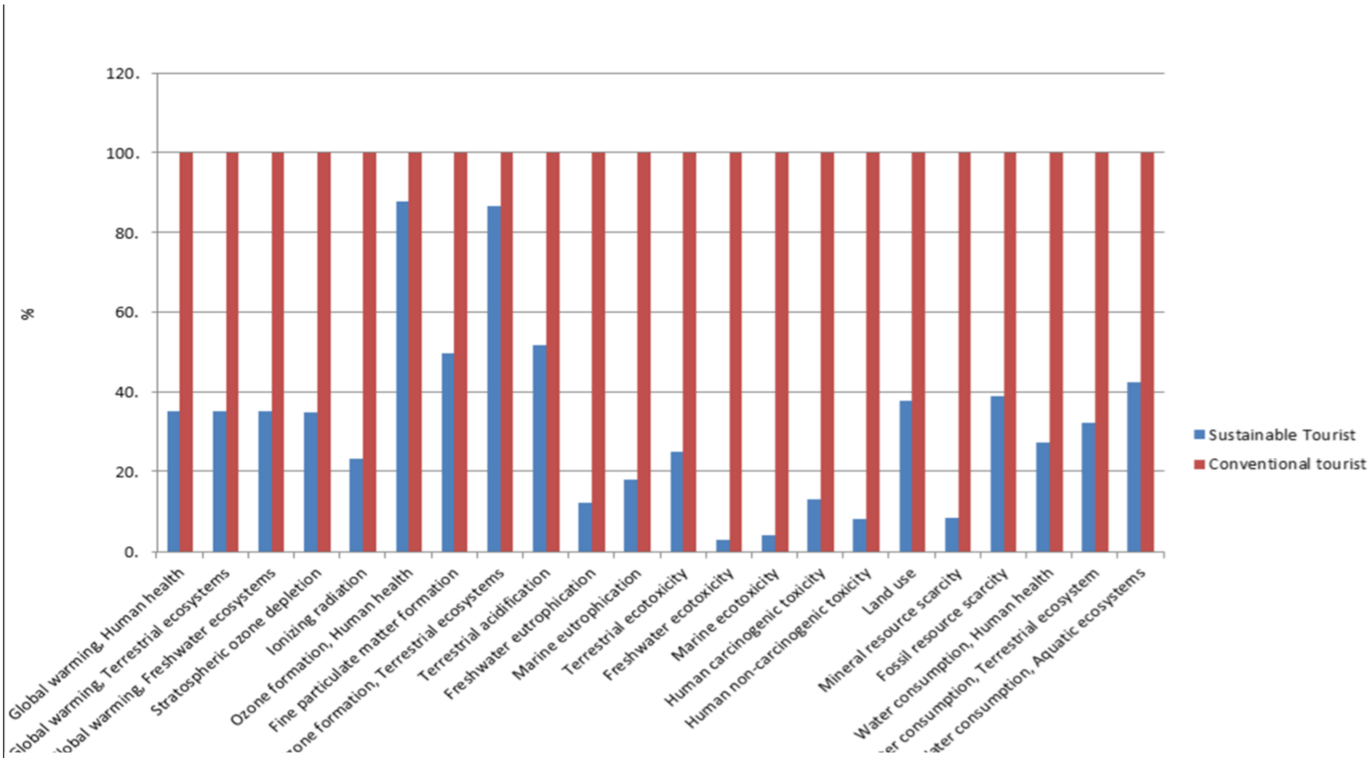
- **Encouraging Behavioural transformations in tourists**

  - **Focusing on heritage and traditions-** Tour operators need to promote heritage walks to introduce **tourists** to the local culture and significance of preserving Ladakh's traditions.

  - **Sustainability centred marketing campaigns-** Marketing strategies for the tourism sector in Ladakh should focus on promoting a low carbon form of tourism. Low carbon modes of transport, use of dry toilets, reduction of single use plastics should be highlighted in campaigns to generate awareness and interest in traditional practices.

[22] https://www.firstpost.com/india/swachh-bharat-mission-forced-ladakh-to-face-hard-truths-about-waste-management-find-traditional-solutions-6275951.html
[23] Interview with Department of Tourism, UT of Ladakh

Life Cycle Assessment of Sustainable Tourism Practices Vs Conventional



The LCA study has been undertaken to understand the implications of sustainable practices on environment. A total of 22 impact categories are assessed following the ReCipe 2016 methodology of LCA analysis. It can be inferred from the above image that all of the impact are significantly decreased if the sustainable practices are adopted by the tourists. The basic assumptions for the analysis are given in table.

Indicator	Traditional Tourist	Sustainable Tourist
Duration of stay	5 days	5 days
Accommodation	2** hotel	Homestay
Water Consumption	135 L/day	75 L/day
Electricity Consumption	30 kwh per day	10 kwh per day
Mode of Local Transport	Taxi/SUV diesel based	Public/ Electric mode of transport
Total distance travelled	908 kms	908 kms
Waste generated per day	250 gms per day	Nominal

Basic Assumptions for Analysis

Figure 25: Life Cycle Assessment of Sustainable Tourism Practices Vs Conventional Practices

Chapter 6: Conclusion

Carbon neutral strategy document has tried to estimate the emissions associated with activities related to fossil fuel consumption. With the elevation of the region as a Union Territory with its two existing districts of Leh and Kargil, it is anticipated that the region will attract even more attention and attraction as a destination to explore new opportunities thereby increasing economic activities which has direct bearing on the region's future carbon profile. The present study finds the current state of Ladakh as carbon negative. The low carbon footprints of Ladakh are attributed to the low level of development in the region, which after the elevation of Ladakh as UT is expected to rise faster than the trend seen in the past few years. Under a baseline scenario Ladakh will lose its carbon neutral status in the next 13 to 14 years. Aggressive development and increasing tourist arrival can accelerate the emission loads and Ladakh may become carbon positive sooner. Low emission development is explicitly stated as the driver of carbon neutrality, which will majorly include the pathways devised in the alternate scenario. The region continues to stay carbon negative till 2050 under this scenario.

There are however enough opportunities that needs to be exploited appropriately in the cold desert for achieving environmental sustainability. The recommendations are based on a thematic approach and cuts across various sectors. All measures proposed are intrinsically linked to the 2030 development agenda, since they will help in reducing risks to human and animal lives while increasing livelihoods and increase the resilience of communities from potential dangers of climate change. Mitigation and adaptation should go hand in hand, as some adaptation measures can contribute to reducing GHG emissions. A thematic approach has been adopted in proposing selected mitigation and adaptation strategies that will cut across various sectors and help build better resilience to communities in the UT of Ladakh.

6.1 Hydrogen as a resource for supporting energy transition

Hydrogen can prove to be game changer. It has the potential to find its environmental benefits in sectors and application like power generation, transportation and indoor heating in commercial and residential sector. Use of Green hydrogen that is produced locally can be promising sustainable source of energy in Ladakh. Local production of Hydrogen will significantly reduce the transportation fuel cost while reducing emissions.

The short term strategy need to focus on demonstration of pilots in selected sectors based on proven Indian feedstocks and technologies. The midterm strategy needs to focus on establishing linkages between hydrogen production (largely decentralized) and end use application. Long term strategy (usually more than 5 to 7 years) needs to focus on expanding and commercial use of hydrogen energy in the transport sector and power generation.

6.2 Climate resilient sustainable agriculture practices

Most of the regions in Ladakh practice mostly mono-cropping with wheat and barley as the major crops. The major sources of irrigation are river based. The predominant types of irrigation systems in the valley include glacier and snow-fed. The concept of artificial glacier is slowly gathering momentum to facilitate conservation of winter water and minimize water shortage during the summer months. The key strategies identified for this sector include employing more climate friendly farming systems through use of composted manures in agricultural soils and funding for research into agro-ecology, agro forestry, increase in resource efficiency practices in agricultural sector through adoption of organic manures, bio-fertilizers and bio-pesticides. There should be target based used of renewable energy technology for water pumping for agriculture as well as adoption of low cost passive solar greenhouse.

6.3 Steering towards sustainable urban development services

Growing urbanization, vibrant tourism sector, limited availability of water, construction materials, poor availability of waste water and waste management infrastructure is posing major challenge to sustainable urban development. The identified strategies for strengthening water infrastructure includes institutional interventions such as installation of water meters at the Service Reservoir level, establishment of Decentralized Wastewater Treatment Systems (DEWATS) and re-use of treated waste water in agriculture, horticulture in hotels for non-potable purposes. In order to reduce water losses, water meters need to be installed in the service reservoirs to monitor the inflow and outflow of water from the reservoir. The target of providing 27X7 water supply has to be associated with large scale water metering and reducing unaccounted water. There should be critical evaluation of all proposed infrastructures where adequate incentives are required to ensure that certain share of the built up area uses local and climate resilient infrastructure. Financing can be provided from property taxes that are less energy and resource efficient. Solar passive heating has the ability to reduce substantial energy consumption and model construction byelaws are the need of the hour to increase share of such commercial and residential buildings. The strategic recommendations for this sector primarily cater to promoting decentralised waste management practices to decrease collection time and increase efficiency, building necessary waste recovery infrastructure, incentivising segregation of waste at source, upscaling of landfills and utilisation of construction and demotion (C&D) waste.

6.4 Greening transport sector in Ladakh

At present, the public transport system in Ladakh is not adequate enough to support the increased footfall of tourists especially during the peak seasons. Some of the more commonly used vehicles include commercial taxis, campers, cabs and motorbikes. Hence a low carbon transition in this sector is anticipated.

The primary challenges for transport includes lack of dedicated parking spaces to accommodate the increased number of commercial vehicles, environmental challenges emanating from higher usage of BS3 and BS4 vehicles and unavoidable challenges faced due to the cold weather and mountainous terrain.

Some of the identified strategies identifies for the sector includes adoption of electric vehicles (EVs) through a phased manner, promotion and adoption of hydrogen fuel for large vehicles such as trucks, use of biofuels, undertaking fleet modernisation to dismantle older vehicles, creating collection centres for end-of-life vehicles and expanding the public transport system by connecting all the major routes.

6.5 Harnessing renewables for climate friendly electricity sector

The region has an immense potential for development of renewable sources of energy such as solar. The recent infrastructure creation for harnessing solar energy in the region is commendable.

However, certain persistent challenges in the region mar the full capacity utilisation of solar sources. These challenges pertain to infrastructure such as access to grid electricity and transmission, environmental challenges such as dependence on diesel generator sets and increased usage of fossil fuels for heating purposes.

The key strategies for a carbon neutral transition in energy sector is based on the hierarchical principles of avoid, reduce, replace and finally offset. Some of the identified strategies for this sector include development of large RE parks primarily based on solar, creation of large scale energy storage facilities to ensure electricity to non-grid regions, strengthening of existing grid to minimise transmission losses, providing fiscal incentives for accentuating usage of renewable energy for domestic requirements.

6.6 Adoption of Sustainable Tourism practices

The sector is witnessing increased tourist footfalls, especially domestic tourists in the past five years with the peak months catering from May to September every year. However, the sector at present is not adequately capacitated to manage the heavy inflow of tourists.

The primary challenges include indiscriminate extraction of groundwater by commercial establishments, lack of monitoring tools for water usage, high energy intensive activities in hotel and transport sectors, improper management systems to tackle the volume of solid waste generated by the tourists.

Some of the identified strategies for this sector include policy level interventions such as popularising home stays, incentivising non-motorise and electric modes of transport through subsidies, increasing pipe water connections, regularise the process of approval of groundwater extraction, regulating tourist movements in fragile ecological zones and defining carrying capacity for a region wherever necessary. The recommended institutional interventions at the UT level include promoting zero emission recreational activities, upgrading the necessary infrastructure pertaining to solid waste management such as deployment of waste collection vehicles, segregation of the waste at source, recovery of essential materials, recycling of waste and finally safe disposal of unrecyclable waste. Similarly at the establishments' level include Mandatory Installation of solar panels and water meters, promoting dry toilets for tourists and incentivise tourists to adopt sustainable practices through imposition of pricing mechanisms such as provision of discounts, redeemable credit points and pay as you use etc.

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Annexure

Additional case studies: Transport sector

Transport Sector

According to IEA 2019, "In the transport sector, besides the first mass-produced hydrogen passenger cars from Toyota, Honda and Hyundai (among others), hydrogen trucks are also being developed to decarbonise road transport of goods (Forbes, 2019). Currently, mid-size hydrogen FCEVs are offered at a premium cost, around 50% more than similar internal combustion engine (ICE) vehicles, although with scaling up production costs would decrease significantly. The key competition would be Battery-electric vehicles in the urban mobility sector that are fast capturing passenger sector.

"Long-distance, heavy-duty transport is potentially a more attractive market for FCEVs (IRENA, 2018a). Hydrogen buses are already widely deployed, and several hundred are on the roads in certain Chinese cities. A new H2Bus consortium in Europe was also recently announced, aiming for 1000 commercially competitive buses fuelled with hydrogen from renewable power, the first 600 of which are due by 2023."

Space Heating

"In the UK, the role of hydrogen in combination with existing natural gas distribution infrastructure has been thoroughly explored in a region of 5 million inhabitants as a key option for decarbonisation of heating, and a large-scale pilot project is scheduled in the north of England (CCC, 2018; Sadler et al., 2018)"

H-vision initiative in Netherlands

H-vision is the first potential blue hydrogen project in the Rotterdam harbour, the Netherlands. The goal is to realise the complete project by 2030. The consortium contains 14 parties from within the harbour as well as parties in the entire process chain. A feasibility study was undertaken in 2018 and the initiative is to launch four steaming reforming plants with a capacity of 15-20 tonner of hydrogen per hour and store the CO2 under the North Sea and deliver to industrial consumers. The first plant is set to open b 2025 with distribution to industries and at the harbour. The final goal is to capture and store 8 Mt of CO_2 per year, for which the co-operation of power plant owners in the harbour is needed (Cappellen et al., 2018).

Source- IEA 2019, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Hydrogen_2019.pdf

Additional case studies: Transport sector

Creating Awareness and Interest- Case of Nordic/EU Countries

Fostering of bicycle use in Schools and also in offices such as government offices would enable faster adoption. For instance, Walk and Cycle to School in Eskilstuna, Sweden is a good example for slowly and steadily raising the interest of the younger generation in cycling. "Cycle pools and CyGo's (a school bus in the form of a chain of parents walking or cycling the children to school) were organized. The intervention targeted elementary school children aged 9–12 years, their parents and school staff." Cycling as a mode of transport slowly picked up with several municipalities in Sweden adopting the intervention. Influencing younger generation to adopt walking and cycling will prove significantly effective.

To avoid congestion in key areas office goers were encouraged to cycle once a week, Countries such as Denmark, Netherlands, Finland and other EU countries such as Belgium, Portugal have launched several initiatives to promote cycling and walking including competitions, prizes, free access to public transport on stipulated days and encouraging companies to promote cycling amongst employees to reduce carbon footprint.

Provision of Incentives – Case of Washington DC

Washington DC has public bike sharing programme called Capital Bikeshare that provides community bike sharing programme. The programme introduced a low cost membership for low income earners. The annual membership costs for the programme were reduced to increase access

Public Bicycle Sharing System- Case of Chennai

In 2018, Chennai became the first city in India to adopt non-motorized transport policy. The city has already undertaken initiatives such as the construction of pedestrian friendly walkways and modernization of bus shelters to increase use of public transport. The Public bicycle sharing system was envisaged to reduce dependence on motorised vehicles, improve last mile connectivity and ensure emission reduction. The project has a plan of 5000 cycles across 275 parking areas in the city. This is currently the largest tendered public cycle sharing system in India as on 2018. These bicycles look different from normal bicycles, are geotagged, have real time monitoring and are linked to smart technologies including smart cards and app with possibility for auto deduction of charges.

Additional case studies: Transport sector

Deployment of Electric Vehicles- Case of Norway

Norway is considered one of the primary capitals of EV deployment and paves the way for EV penetration. Bergen and Oslo both have consistently increased their EV share in the global market. In 2019, 67% of passenger vehicle sales was electric in Bergen in 2019 and 64% in Oslo. Both the cities also stand out with most number of vehicles at 25 for each public charger. Both the cities also have a target of reaching 100% EV share in sales of passenger and commercial vehicles sales by 2022.

To enable EV adoption, there is need to employ several supporting policies to increase uptake. One key action that has been taken by most of EV implementing cities is to create Low- and zero-emission zones. These zones will only allow vehicles that low or zero emission based. Oslo has signed the Fossil Fuel Free Streets declaration, a mayor level commitment to procure zero emission buses by 2025. While Oslo is planning such zones, Bergen has already implemented and assigned certain parts of the city center as zero emission zones.

Electrification of public transportation and other transport fleets such as Taxis, light vehicles is also a major goal for these two cities. Both cities Bergen and Oslo intend to electrify their fleets by 2024. These cities have also adopted innovative policies to enhance charging infrastructure including home charging stations, stations for multi-unit dwellings and strict building codes with many of the building spaces to ensure 100% compliant and suitable for enabling charging infrastructure.

It should be noted that much of the EV adoption policy in both the cities has been steered by local government initiative highlighting the strong role and impact of city and region based initiatives leading to high impact.

Financial and Non-Financial Incentives

- Some major EV deploying capitals in the world provide subsidies or tax reduction for the purchase of EV vehicles.
- In certain countries, Electric vehicles are provided free or parking at reduced costs, in some countries certain parking zones are reserved for EV owners.
- In the case of Norway, the local governments have either waived off or reduced tolls for bridges, ferries and tunnels

ICCT BRIEFING | ELECTRIC VEHICLE CAPITALS: CITIES AIM FOR ALL-ELECTRIC MOBILITY

https://theicct.org/sites/default/files/publications/ev-capitals-update-sept2020.pdf

https://www.nordicenergy.org/wp-content/uploads/2018/05/NordicEVOutlook2018.pdf

https://theicct.org/sites/default/files/publications/World-EV-capitals_ICCT-Briefing_08112017_vF.pdf

Additional case studies: Electricity sector

Power Sector Reforms- Case of Morocco

Morocco's experience with power sector reforms led to significant private participation in the sector and unbundled electricity generation and distribution segments. The share of public company ONEE in the power sector has reduced drastically from 90 % in 1991 to 30 percent in 2017. On the other hand private generation currently stands at 50.8 percent of the gross output.. Morocco also achieved rural electrification with 99.5% access in 2017 for 2.1 million households. Th renewable energy strategy of Morocco has led to increased decarbonisation. According to a World Bank Policy brief, "Renewable energy – including hydro, solar and wind – constitutes almost 2,696MW (34 percent) of installed generation capacity, a rate higher than some OECD countries, and is on course to reach 3,769MW (42.7 percent) by 2020 as articulated in the country's renewable energy strategy". While the country is stil fossil fuel heavy, yet the reforms have led to dramatic changes in the energy mix and its distribution.

Source- Lessons from Power Sector Reforms The Case of Morocco, World Bank 2019

https://openknowledge.worldbank.org/bitstream/handle/10986/32221/WPS8969.pdf?sequence=6&isA