



**GOVERNMENT OF NEPAL  
WATER AND ENERGY COMMISSION SECRETARIAT  
SINGH DURBAR, KATHMANDU**



**MASTER PLAN  
FOR PUBLIC CHARGING INFRASTRUCTURE (PCI)  
ON MAJOR NATIONAL HIGHWAYS  
FOR ELECTRIC VEHICLES (EV)**

**FINAL REPORT**

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## EXECUTIVE SUMMARY

This report outlines a comprehensive master plan for the systematic development and deployment of public Electric Vehicle Charging Stations (EVCS) across Nepal's National Highway network, in alignment with the Strategic National Highway (SNH) 2020/21 framework. In response to the accelerating adoption of electric vehicles (EVs) within Nepal, this plan addresses the urgent requirement for a reliable, accessible, and resilient public charging infrastructure that supports sustainable mobility, reduces greenhouse gas emissions, and enhances national energy security.

### **Study Area and Site Selection**

Covering 80 national highways, the plan identifies 424 priority EVCS locations selected through rigorous Geographic Information System (GIS) analyses, extensive field surveys, stakeholder consultations, and multi-criteria decision-making methodologies, notably the Analytic Hierarchy Process (AHP). Site selection criteria systematically incorporated factors such as traffic density, land availability, flood risk, road gradient impact on EV range, and proximity to existing electrical grid access points to maximize usability and reliability.

### **Regulatory and Technical Framework**

A critical component of the master plan is the establishment of a comprehensive regulatory framework. This framework includes the formulation of stringent technical standards and safety guidelines for public charging infrastructure, focused on equipment interoperability, charger classification (AC/DC, fast/slow), and alignment with the Nepal Electricity Authority's Electricity Distribution Regulation, 2078, alongside relevant international standards from neighboring countries such as India and Bangladesh. Detailed grid connection standards govern parameters including power factor, harmonics, load factor, and voltage deviations to secure stable grid integration and mitigate operational risks.

### **Phased Rollout Strategy**

The deployment plan is structured over a 10-year horizon divided into three phases to ensure efficient, scalable implementation:

*Phase I (Years 1–3):* Installation of 168 EVCS concentrating on areas with sufficient existing grid capacity to enable immediate rollout.

*Phase II (Years 3–6):* Deployment of 123 additional EVCS, incorporating grid reinforcements in selective locations.

*Phase III (Years 6–10):* Completion with 133 EVCS installations supported by smart grid upgrades and renewable energy integration to facilitate heavy vehicle fast charging demands.

This phased approach balances immediate infrastructure needs with longer-term grid adaptability and system resilience.

Nepal's EV adoption is forecasted under three scenarios—Business as Usual, NDC 3.0, and Net-Zero—showing increasing electrification and infrastructure needs through 2035. Energy demand for charging could rise from 427 MWh (2025) to over 8,000 MWh (2035), enabling up to 1,873 kt of CO<sub>2</sub> emissions reduction annually. Achieving these goals requires strong policies, investments, and expanded charging networks to support sustainable transport decarbonization.

### **Land Use and Institutional Coordination**

Recognizing land acquisition as a key challenge, the plan proposes pragmatic strategies including leveraging public lands, optimizing leasing arrangements, and fostering efficient inter-agency collaboration to streamline site preparation, approval processes, and operational readiness. These measures aim to expedite deployment while mitigating land-related delays and conflicts.

### **Data Infrastructure and Monitoring**

The master plan calls for the establishment of a centralized national online database with restricted access to relevant government agencies. This platform will enable real-time monitoring, data-driven decision making, and policy adjustments by consolidating information across all public EVCS sites, thereby improving transparency and operational management.

### **Financial Sustainability and Implementation Model**

To promote economic feasibility and private sector participation, the plan strongly recommends adoption of a Public-Private Partnership (PPP) model. This approach intends to balance risk-sharing, enhance technical expertise, and maintain public oversight to ensure service quality and long-term operational sustainability.

### **Conclusions and Recommendations**

The master plan provides a pragmatic, data-driven blueprint for scaling Nepal's EV public charging infrastructure, directly contributing to its clean transport transition and enabling significant CO<sub>2</sub> emissions reduction. Critical success factors include adherence to stringent safety and interoperability standards, phased infrastructure deployment responsive to grid capacities, proactive land management, centralized data oversight, and robust financial frameworks leveraging private investment. The plan underscores the importance of continuous master plan revisions to accommodate emerging technologies, evolving market dynamics, and new policy imperatives, thus guaranteeing Nepal's EV ecosystem remains adaptive, resilient, and aligned with national sustainability goals.

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**LIST OF ABBREVIATION**

<b>Abbreviation</b>	<b>Full Form</b>
2Ws	Two Wheelers
3Ws	Three Wheelers
4Ws	Four Wheelers
AC	Alternating Current
AADT	Annual Average Daily Traffic
AHP	Analytical Hierarchy Process
AEPC	Energy Promotion Centre
BAU	Business As Usual
CPOs	Charge Point Operators
DC	Direct Current
DoR	Department of Roads
DT	Distribution Transformer
DEM	Digital Elevation Model
DMG	Department of Mines and Geology
DOLMA	Department of Land Management and Archive
DOS	Department of Survey
DOTM	Department of Transport Management
EV	Electric Vehicle
ECS	Equivalent Car Space
EVCS	Electric Vehicle Charging Station/Infrastructure
EVSE	Electric Vehicle Supply / Service Equipment
ESA	European Space Agency
FC	Fast Charging
FY	Fiscal Year
GWh	Gigawatt hour
GoN	Government of Nepal
HT	High Tension

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kV	Kilovolt
kVA	Kilovolt Ampere
kW	Kilowatt
kWh	Kilowatt hour
LCV	Light Commercial Vehicles
LEV	Light Electric Vehicles
MoU	Memorandums of Understanding
MCDA	Multi-Criteria Decision Analysis
MOLCPA	Ministry of Land Management, Cooperatives and Poverty Alleviation
MoEWRI	Ministry of Energy, Water Resources and Irrigation
MoEST	Ministry of Education, Science and Technology
MoPIT	Ministry of Physical Infrastructure and Transport
MoF	Ministry of Finance
NEA	Nepal Electricity Authority
NOC	Nepal Oil Corporation
NPC	National Planning Commission
NZE	Net Zero Emission
NH	National Highway
NRIW	Normalized Relative Importance Weight
PCI	Public Charging Infrastructure
PCS	Public Charging Stations
PPP	Public Private Partnership
SD	Sustainable Development
SC	Slow Charging
SWOT	Strength Weakness Opportunities Threats
SRTM	Shuttle Radar Topography Mission
THD	Total Harmonic Distortion
TOD/TOU	Time of Day/Time of Use

TOR	Terms of Reference
USGS	United States Geological Survey
WECS	Water and Energy Commission Secretariat

## CHAPTER 1: INTRODUCTION

### 1.1 BACKGROUND

The Water and Energy Commission Secretariat (WECS) was established by the Government of Nepal (GoN) with the mandate to promote the integrated and accelerated development of the nation's water and energy resources. WECS plays a key role in assisting the GoN and relevant ministries in policy formulation and project planning within these sectors. Additionally, it serves as a technical advisory body, providing recommendations on bilateral and multilateral matters related to water and energy resources.

Recognizing the urgent need to reduce greenhouse gas emissions in line with its climate change commitments, the Government of Nepal has identified electric vehicles (EVs) as a strategic solution for decarbonizing the transportation sector. Although EVs were first introduced in the Kathmandu Valley in 1993, it is only in recent years that they have gained broader attention across the country. Originally targeted at reducing urban pollution, EVs have proven to be both cost-effective and environmentally beneficial.

Despite these advantages, including various tax and financial incentives provided by the government, public adoption of EVs remains limited. A key barrier is the lack of an adequate and reliable EV charging infrastructure, particularly along major travel corridors. To address this gap, this Master Plan has been developed to guide the establishment of a robust network of fast-charging stations across Nepal's major National Highways.

Currently, Nepal lacks specific standards and guidelines for the planning, design, installation, and operation of EV charging infrastructure. To address this regulatory shortfall, Draft Guidelines for Electric Vehicle Infrastructure have been prepared. These guidelines are intended to ensure that charging stations are designed to be accessible, safe, and user-friendly for all EV users. They cover essential components such as station layout, site accessibility, and user information requirements before, during, and after charging.

While not exhaustive, the guidelines are designed to serve as a practical reference for all stakeholders involved in the development of EV infrastructure. They should be applied wherever possible and adapted to local conditions as needed. In future, all publicly funded EV charging station projects will be required to comply with these guidelines. Moreover, minimum technical standards will be formulated to further ensure consistency and accessibility in implementation.

The overarching aim of this framework is to support the nationwide rollout of inclusive and efficient EV charging infrastructure that meets the diverse needs of users across various regions and communities. The contribution of all stakeholders involved in the preparation of this framework is gratefully acknowledged.

An inclusive EV infrastructure will empower individuals, communities, businesses, and stakeholders to transition toward electric mobility, thereby stimulating economic growth and reducing dependency on fossil fuels

## **1.2 OBJECTIVES**

The master plan foresees the installation of EV charging stations on the national highways of Nepal. The charging stations will primarily be installed at optimum intervals between 25-100 kilometers near highway intersections and towns along Nepal's national highways. Some of the specific objectives of the master plan are enlisted below.

- To promote the rapid adoption of electric vehicles in Nepal by ensuring safe, reliable, accessible, and affordable charging infrastructure along national highways.
- To initially assist the establishment of EV charging stations and, eventually, to develop a market for the EV charging business.
- To support the cost-effective and timely rollout of EV charging infrastructure, encouraging parallel investments from private sectors.
- To build an adequate EV charging station network to enable EV rollout.
- To encourage electricity distribution system readiness to adopt new demand created by EV charging stations.

## **1.3 SCOPE OF WORK**

The scopes of this master plan are:

- Preparation of Standards/ Guidelines for Public Charging Infrastructures.
- Regulations regarding connectivity with the grid such as power factor, load factor, harmonics, voltage deviations, etc.
- Safety standards are required for the grid to be ensured through existing regulations.
- Standards/ specification of equipment/ products to be used in charging infrastructure considering the interoperability of the device and the agency responsible for it.
- Specifications for the fast and slow charging and AC and DC chargers.
- Assessment of the capacity of the distribution network to supply the load of electric vehicles.
- Identify the optimum number and suitable locations, density, and penetration of the charging infrastructure along National Highway as per statistics of National Highways (SNH 2020/2021).
- Priority of rollouts of EV public charging infrastructures.
  - Phase I (1-3 years)
  - Phase II (3-5 years)
  - Phase III (5+ years)
- Propose suitable implementation plan for the above identified charging infrastructures.
- Assess the stability and adequacy of the existing power source, which will connect the charging stations to the grid.
- Perform a Grid Impact Study (GIS) of the heavy vehicle integration since they need extremely fast charging, that results in very high charging loads (at the multiple-megawatt scale) if many such vehicles charge simultaneously.
- Assess the availability of suitable land/ location and the appropriate mode of obtaining land (leasing or using public lands).

- Perform an assessment of “Road Gradient” on the mileage of EVs while accessing the location of the charging infrastructures.
- Create and maintain a Safe National Online Database (having restricted access to concerned authority) of all the public Charging stations.

#### **1.4 STUDY AREA**

The study area for this master plan encompasses Nepal’s entire National Highway network, as defined in the Statistics of National Highways (SNH 2020/2021), which extends over approximately **14,913 kilometers** and includes a total of **80 national highways**. This extensive network forms the backbone of Nepal’s road transport system, serving as the principal corridors for the movement of people and goods across the country. These highways connect the eastern, western, northern, and southern regions, linking major cities, market centers, border crossings, and remote rural settlements, thereby playing a critical role in national economic development and regional integration.

Given the strategic importance of this network, the focus of the study is to systematically identify, prioritize, and plan the deployment of public electric vehicle (EV) charging infrastructure along these routes. This will involve a multi-criteria assessment framework that considers key factors such as traffic volume and vehicle density, geographic and topographic conditions (including elevation changes and road gradients), proximity to existing grid infrastructure, and availability and suitability of land for charging station development. Special attention will be given to high-demand corridors and major junctions where vehicle flow is highest and where the integration of charging infrastructure will yield maximum benefit in terms of user convenience and network efficiency.

The plan will emphasize a **phased deployment approach**, beginning with pilot corridors and expanding progressively based on demand forecasts, technological readiness, and grid capacity. The study will also analyze the compatibility of proposed charging sites with Nepal’s existing power distribution system to ensure that the additional electrical loads can be managed sustainably, minimizing adverse impacts on local grids and ensuring reliable service delivery.

Furthermore, the master plan will integrate broader **policy objectives**, such as supporting the Government of Nepal’s climate change commitments and national targets for increasing the share of electric vehicles in the transport sector. By creating a robust, accessible, and strategically located EV charging network, this initiative aims to accelerate the transition to low-emission mobility, reduce dependency on imported fossil fuels, and promote balanced regional development.

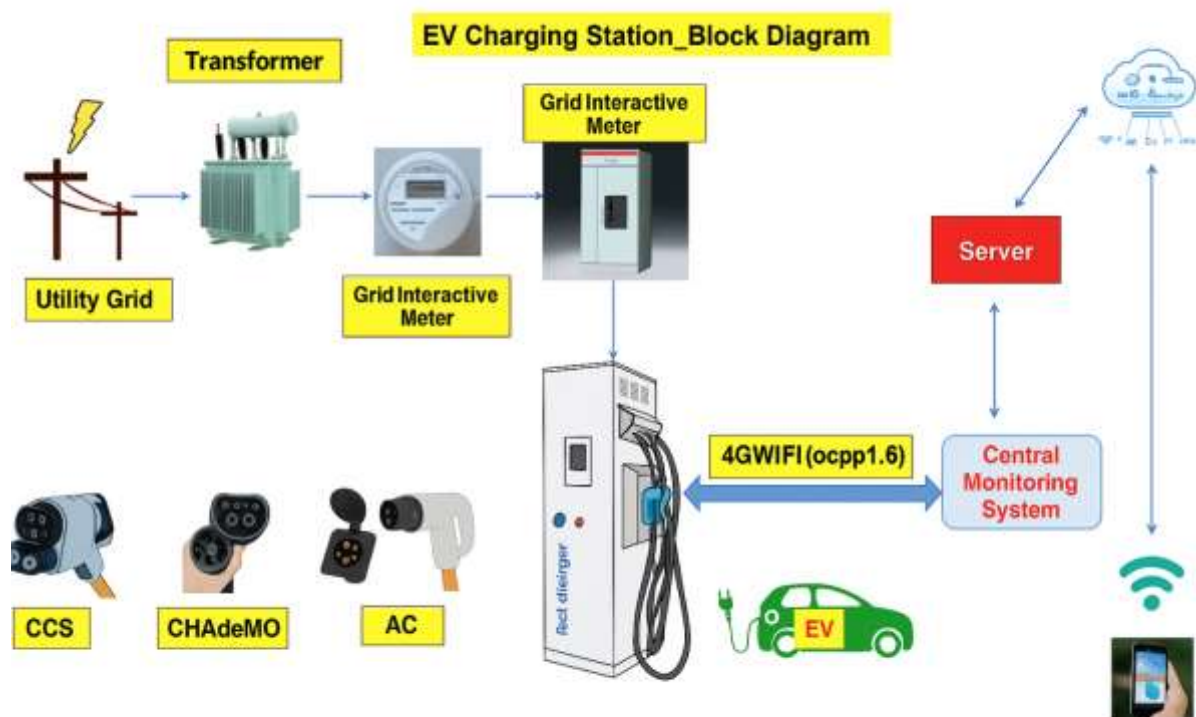
Overall, this comprehensive planning effort will provide a clear roadmap for stakeholders—including government agencies, power utilities, local municipalities, private investors, and development partners—to coordinate investments and actions needed for the sustainable and widespread adoption of electric vehicles along Nepal’s national highway system.

## CHAPTER 2: LITERATURE REVIEW & POLICY ANALYSIS

### 2.1 BASIC CONCEPT OF EV PUBLIC CHARGING INFRASTRUCTURES/ STATION AND THEIR ACCESSORIES

#### 2.1.1 Overview/ Block Diagram of EVPCI

A Block Diagram for an Electric Vehicle Public Charging Infrastructure (EVPCI) system provides a high-level view of the components and their interactions in a typical setup. The diagram typically shows the key subsystems and how they communicate to ensure effective charging, grid integration, and user interaction.



Source: NEA Bidding Document for Supply, Delivery, Installation of Charging Station

**Figure 1: Overview of EV Charging Process**

The main component of EVPCI system are described below:

#### 1. EV Charging Station (EVCS)

- **Power Supply Unit (PSU):** Supplies the necessary power to the EV chargers.
- **DC/AC Charger:** Converts the grid power (AC) to DC for the vehicle's battery (for DC fast chargers).
- **Communication Interface (OCPP):** Allows the charger to communicate with a central system using **Open Charge Point Protocol (OCPP)** for remote management and control.
- **Safety and Protection Systems:** Includes overcurrent protection, ground fault detection, surge protection, and thermal management systems.

## 2. Grid Connection

- **Transformer:** A distribution transformer steps down medium voltage (e.g., 11 kV) to low voltage (e.g., 415 V) without altering frequency. In fast-charging stations, its size is selected based on power demand, and the number of units depends on the reliability requirements of the site.
- **Metering:** Measures the electricity usage for billing and monitoring purposes.
- **Power Quality Monitoring:** Ensures voltage levels, harmonics, and overall power quality meet standards.
- **Smart Grid Communication:** Interfaces with the grid operator to manage peak loads and provide demand response.

## 3. Vehicle (EV)

- **Battery Management System (BMS):** Monitors the vehicle's battery health, charging status, and ensures safe charging.
- **On-Board Charger:** Converts DC (if using DC fast charging) or AC (if using Level 2 charging) into a suitable format for the vehicle's battery.

## 4. Central Management System (CMS)

- **Charge Point Management (CPM):** Manages multiple charging stations, schedules charging times, and allocates resources.
- **User Authentication:** Verifies and authenticates users (RFID, mobile app, or payment card).
- **Billing and Payment:** Processes payment transactions for the user based on energy consumption.
- **Reporting & Analytics:** Collects data from EVCS and provides insights on performance, usage, and potential issues.
- **Energy Management:** Optimizes charging patterns, schedules, and integrates renewable energy sources to ensure efficient power use.

## 5. User Interface

- **Mobile App/Website:** Allows users to find charging stations, check availability, and initiate or schedule charging.
- **On-site Charger Interface:** Provides the user with information such as charging status, cost, and time remaining.

## 6. Grid Management (Optional)

- **Smart Metering System:** Enables bidirectional communication between the EV charging station and the grid for energy consumption tracking and grid balancing.
- **Demand Response Management:** Manages grid load during peak demand periods by controlling the charging rates or delaying charging.

## 7. Power Cables for EV Fast-Charging Stations

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Power cables in fast-charging infrastructure connect the grid to the charger and the charger to the EV. For DC charging, cables must comply with **IEC 62893** standards, ensuring safety, performance, and durability.

- **IEC 62893-1** outlines general requirements for AC (Mode 1–3) and DC (Mode 4) cables up to 0.6/1 kV, using Class 5 copper conductors, EVI-2 insulation, and EVM-type sheath.
- **IEC 62893-4-1** covers **DC cables without thermal management**, rated at **1.5 kV DC**, with core sizes ranging from **4–150 mm<sup>2</sup>**, suitable for outdoor use.
- **IEC 62893-4-2** applies to **DC cables with thermal management**, also rated at **1.5 kV**, with enhanced insulation, sensor cores, and fluid-cooling capability to withstand high temperatures.

Cables must be selected based on voltage class, installation conditions, and cooling needs to ensure reliable, safe EV charging. Preferred materials include **EVI-1/2 insulation** and **EVM sheathing**, with optional metallic screening.

## 8. Switchgears

- Switchgears are devices used for protection and control of electrical circuits.
- They safely connect or disconnect circuits during faults or maintenance.
- In EV fast-charging stations, switchgears are installed at:
  - Medium voltage level (distribution transformer HV side)
  - Low voltage level (distribution transformer LV side and outgoing feeders)
  - Between charger output (DC) and EV
- Each charger-to-EV circuit includes:
  - A circuit breaker (compliant with IEC 60947)
  - A Residual Current Device (RCD) of Type A or B, rated  $\leq 30$  mA, as per IEC 60364-7-722

### 2.1.2 Type of EV Charger

EV chargers are categorized based on charging speed, power level, and current type (AC or DC). Here's a breakdown of the main types of EV chargers:

1. Level 1 Charger (AC Charging)
  - Voltage: 120V (standard household outlet)
  - Power Output: ~1.3–2.4 kW
  - Charging Speed: 3–8 km (2–5 miles) of range per hour
  - Use Case: Residential charging, light EV use
  - Connector Type:
    - Type 1 (SAE J1772) – Common in North America
2. Level 2 Charger (AC Charging)
  - Voltage: 208V–240V
  - Power Output: 3.3–22 kW

- Charging Speed: 16–100 km (10–60 miles) of range per hour
- Use Case: Residential, public, workplace charging
- Connector Types:
  - Type 1 (SAE J1772) – North America
  - Type 2 (Mennekes) – Europe, India, and increasingly in Asia (including Nepal)
  - GB/T – Used in China

3. DC Fast Charger (Level 3 Charger)

- Voltage: 200V–1000V
- Power Output: 25–350 kW (or more)
- Charging Speed: 100–300 km (60–180 miles) of range in 20–30 minutes
- Use Case: Public highways, commercial fleets, heavy EVs
- Connector Types:
  - CHAdeMO – Japan (Nissan, Mitsubishi)
  - CCS (Combined Charging System) – Widely adopted globally
  - CCS1 – North America
  - CCS2 – Europe, India, South Asia
  - GB/T DC – Used in China
  - Tesla Supercharger – Proprietary (Tesla vehicles, shifting to CCS2 in many regions)

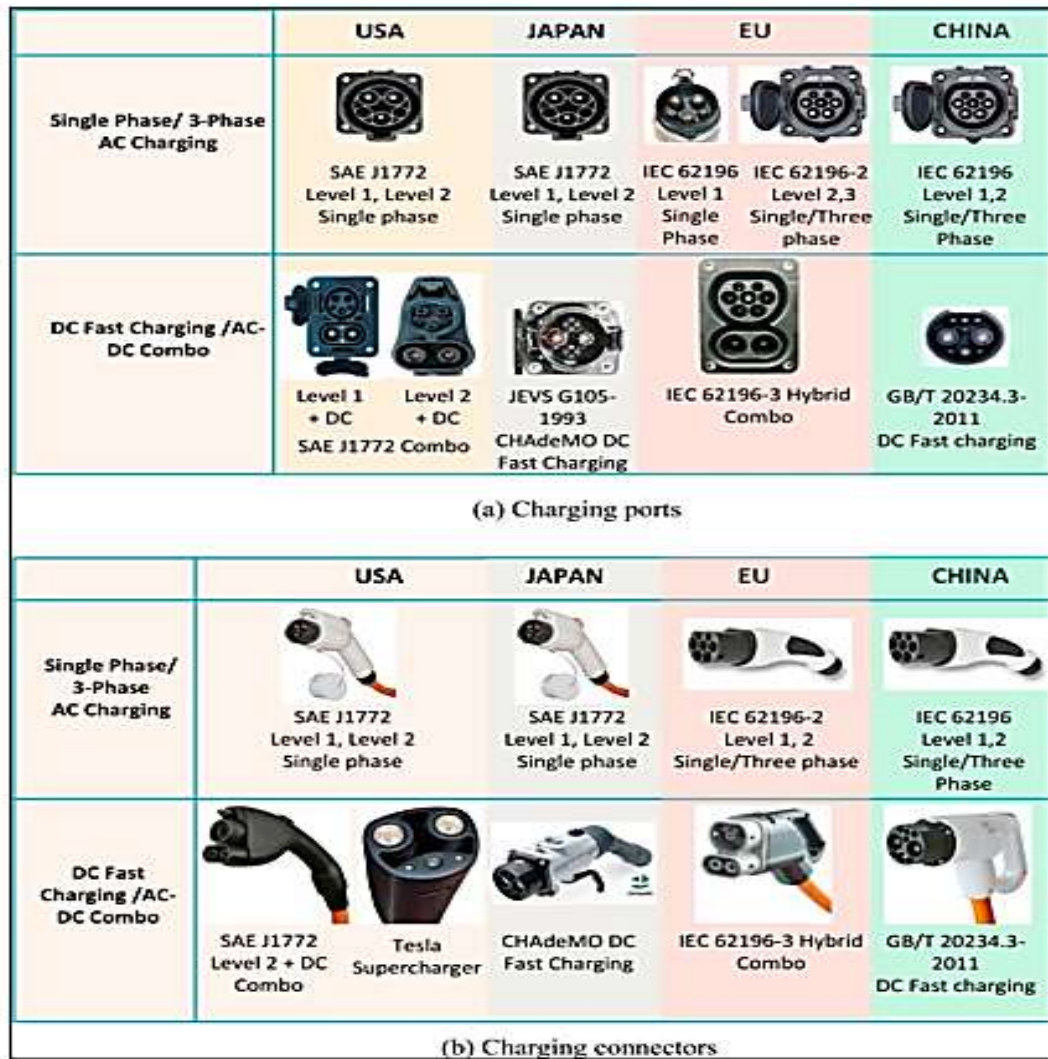
4. Ultra-Fast & Megawatt Chargers (for Heavy Vehicles)

- Power Output: 350 kW to 1 MW+ (e.g., Megawatt Charging System - MCS)
- Charging Time: <30 minutes for buses, trucks, and commercial fleets
- Use Case: Heavy-duty EVs (e-buses, e-trucks)
- Standardization: MCS (Megawatt Charging System by CharIN) in development for global standardization

Types of EV Chargers along with their applications, categorized by charging level, power, and use case ideal for inclusion in your technical report for Nepal’s EV infrastructure planning:

Charger Type	Power Output	Voltage	Charging Time	Application	Connector Types
<b>Level 1 (AC)</b>	1.3–2.4 kW	120V	8–20 hours (full charge)	Home charging, low-mileage personal EVs	Type 1 (SAE J1772)
<b>Level 2 (AC)</b>	3.3–22 kW	208–240V	4–8 hours (full charge)	Residential, workplace, public charging	Type 1 (SAE J1772), Type 2, GB/T
<b>DC Fast Charger</b>	25–150 kW	200–1000V DC	30–90 minutes (80%)	Highway stations, fleet charging	CHAdeMO, CCS1/2, GB/T DC
<b>Ultra-Fast DC</b>	150–350 kW	400–1000V DC	15–30 minutes (80%)	Urban hubs, long-distance travel corridors	CCS2, Tesla (Supercharger), GB/T

Charger Type	Power Output	Voltage	Charging Time	Application	Connector Types
Megawatt Charging System (MCS)	1 MW – 3.75 MW	>1000V DC	15–20 minutes (heavy EVs)	Heavy-duty EVs: buses, trucks, logistics	MCS (under standardization)



Source: Electric Vehicles Charging Stations’ Architectures, Criteria, Power Converters, and Control Strategies in Microgrids, <https://www.mdpi.com/2079-9292/10/16/1895>

Figure 2: Different Types of Charging Ports and Charging Connectors

### 2.1.3 Types of DC Chargers and their Guns

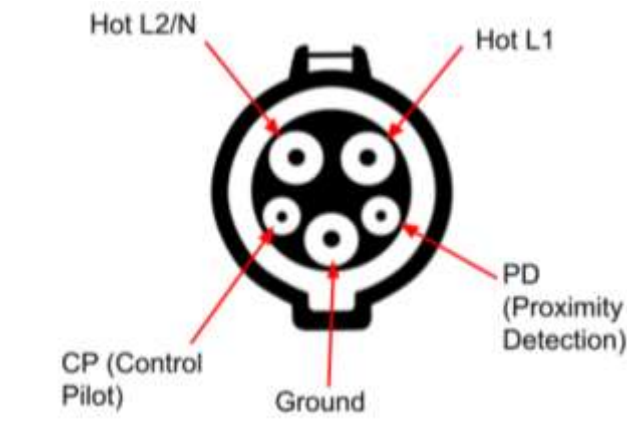
Type	Standard / Region	Max Power	Voltage Range	Use Cases	Connector
CHAdeMO	Japan (Nissan, Mitsubishi)	~50–100 kW	Up to 500V	Legacy fast chargers, Asia	Separate DC plug
CCS Type 1	North America (SAE Combo 1)	Up to 350 kW	200–1000V	Widely used in the US	Combo (AC+DC)

Type	Standard / Region	Max Power	Voltage Range	Use Cases	Connector
CCS Type 2	Europe, India, Nepal, others	Up to 500 kW	200–1000V	Most widely adopted standard globally	Combo (AC+DC)
GB/T DC	China	237.5–250 kW+	200–1000V	Chinese EV market	Separate DC plug
Tesla Supercharger	Proprietary (shifting to CCS2)	V3: ~250 kW	400V–1000V (new models)	Tesla vehicles (global)	Tesla plug / CCS2
MCS (Megawatt Charging System)	Under development (CharIN)	1–3.75 MW	>1000V	Heavy-duty EVs (trucks, buses)	MCS connector

## Details of Each DC Chargers Type

### 1. SAE J1772

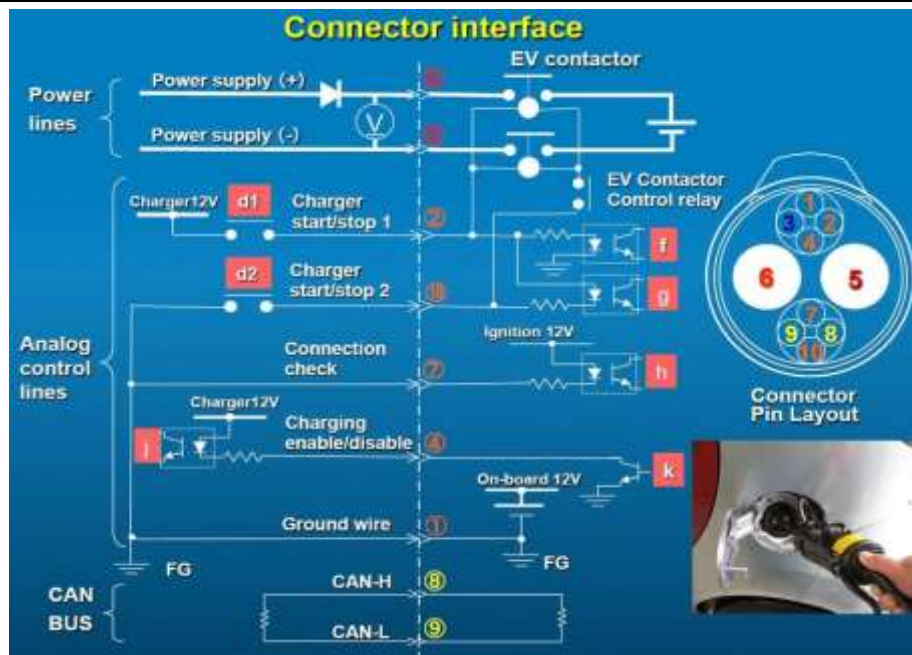
This connector is the industry standard for all electric vehicles performing Level 1 or Level 2 charging. Whether it's the cord provided with the purchase of your EV or the Level 2 charger outside of Whole Foods, the J1772 is going to connect.



Source: [A Technical Analysis of Charging with the J1772 Connector, Kunj Shah, 2021](#)

### 2. CHAdeMO

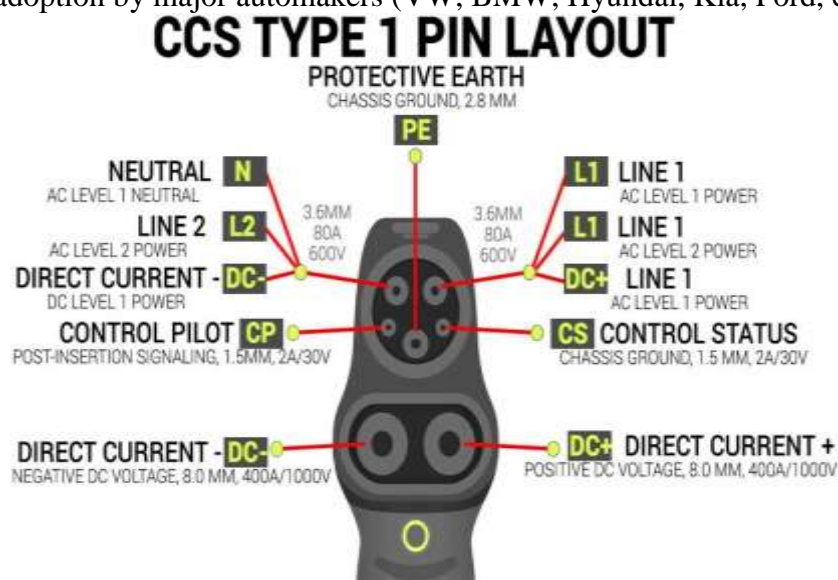
- Developed in Japan.
- Used by automakers such as Toyota, Nissan Leaf, Subaru, Mitsubishi Outlander.
- Bi-directional V2G-ready.
- Phasing out in many countries in favor of CCS.



Source: [Rapid EV Chargers: Implementation of a Charger, Neville Watson & Allan Miller, 2016](#)

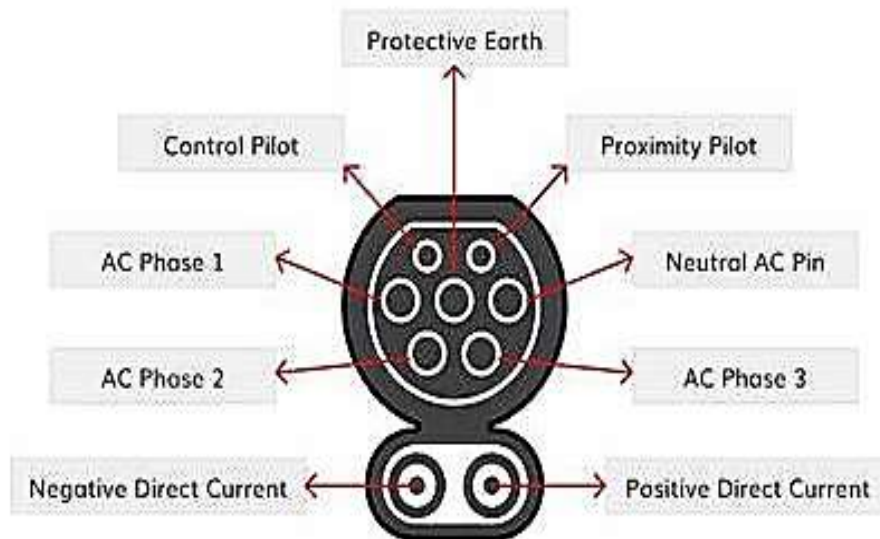
### 3. CCS (Combined Charging System)

- **CCS1:** Used in North America.
- **CCS1:** Used in North America.
- **CCS2:** Widely used across Europe, India, South Asia (Nepal), compatible with AC (Type 2) and DC fast charging.
- High adoption by major automakers (VW, BMW, Hyundai, Kia, Ford, etc.).



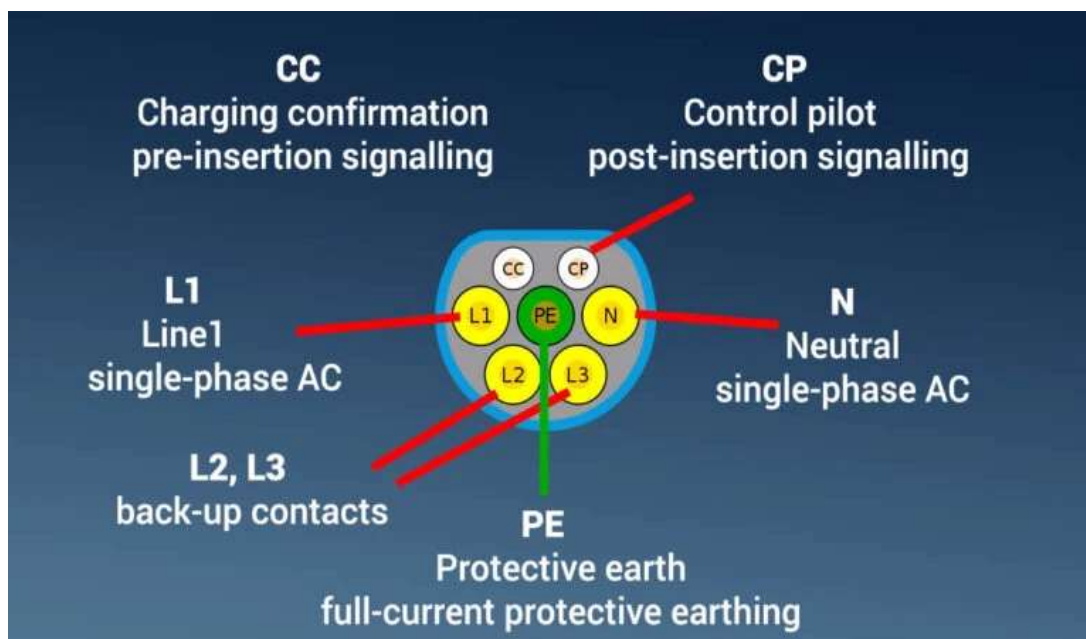
source: <https://www.midaevse.com/news/ccs-type-1-plug-j1772-combo-1-connector-sae-j1772-2009-for-dc-fast-charger-point/>

### CCS Type 2 Pin Layout



#### 4. GB/T (DC)

- Chinese standard.
- Separate DC and AC ports.
- Government-backed and used by most Chinese EVs and chargers.

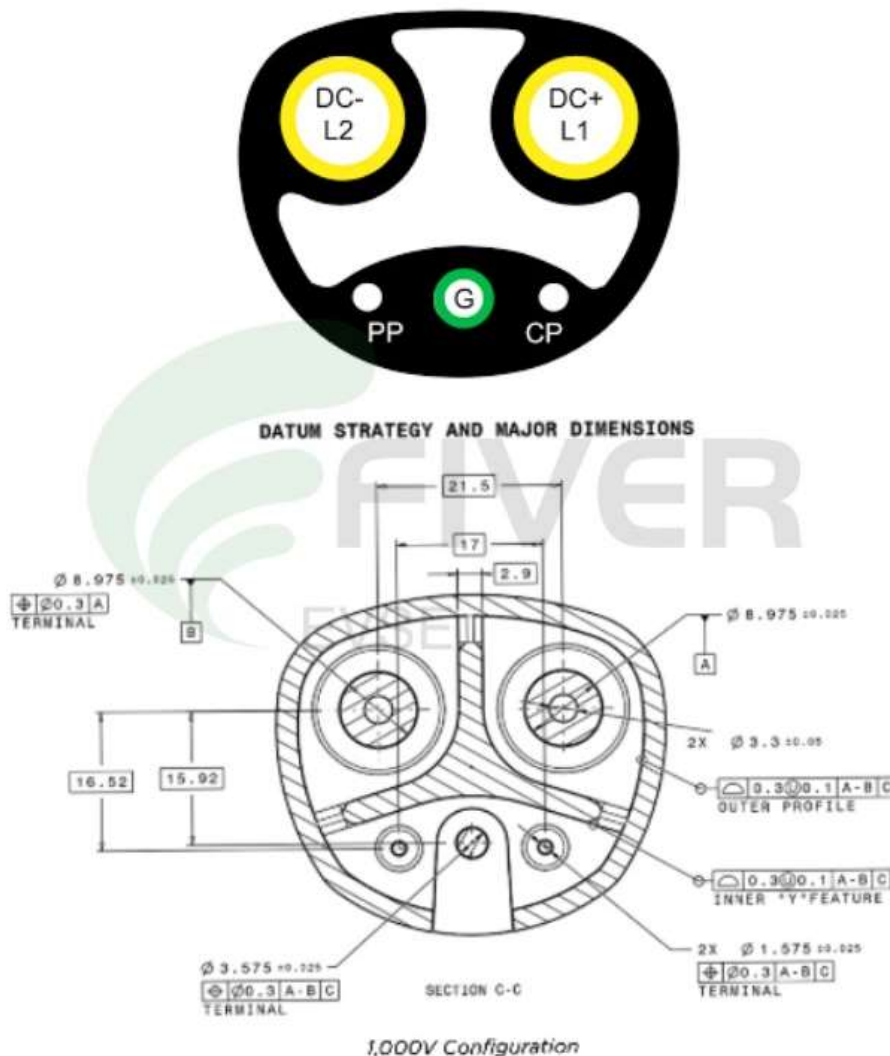


source: <https://www.grasen-power.com/info/what-s-the-gb-t-charging-standard-83302369.html>

#### 5. Tesla Supercharger

- Tesla's proprietary system.
- Tesla is moving toward CCS2 globally for compatibility.
- Supercharger V3 delivers up to 250 kW.

## 1000V DC 250A Tesla NACS Connector Pinout Diagram



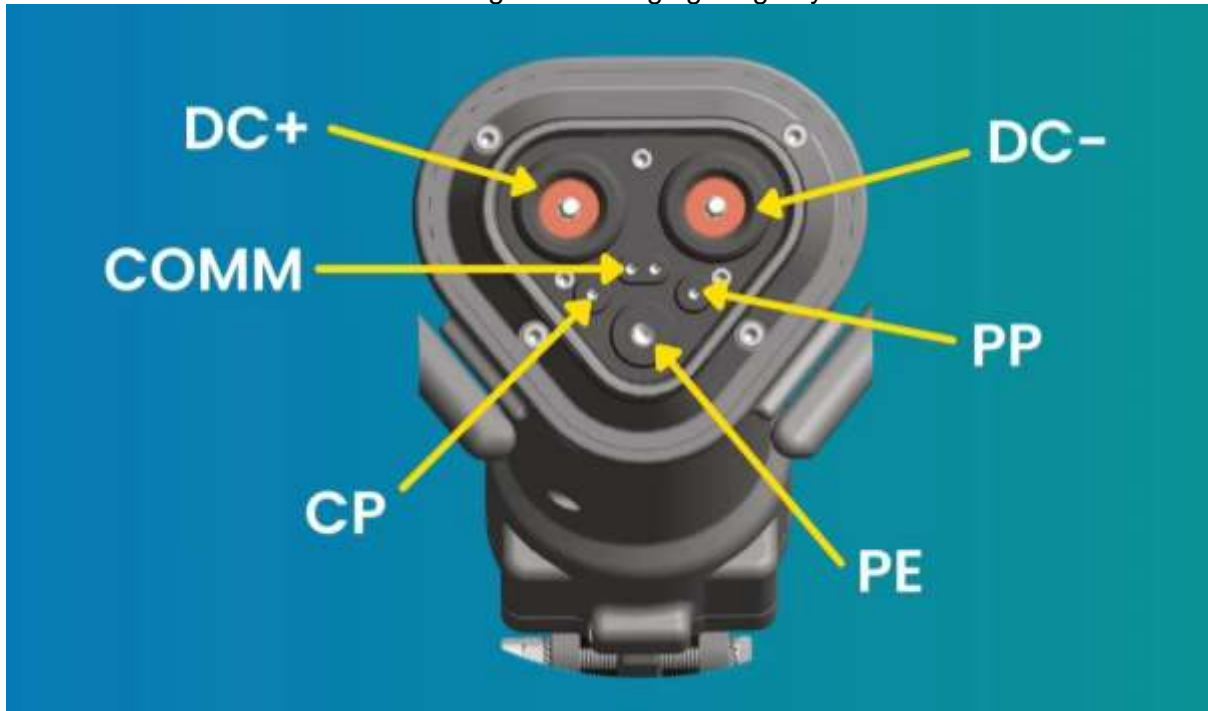
Source: <https://www.fiverevse.com/product/250A-Tesla-Charging-Connector-Replacement-250KW-NACS-Plug-for-DC-Fast-Charging.html>

The North American Charging Standard (NACS) connector has five pins:

- DC+/L1 and DC+/L2: Two primary pins used for both AC charging and DC Fast Charging
  - Ground (G): A pin that eliminates excess charge by dumping it into the road surface
  - CP: Control pilot pin. charging status current signaling.
  - PP: Proximity pilot. vehicle connection status signaling
6. Megawatt Charging System (MCS)

- Still in final standardization (led by CharIN).
- Targeting charging needs of electric trucks, buses, and heavy logistics vehicles.
- Power levels up to 3.75 MW (for ultra-rapid turnaround).
- Planned adoption in future commercial EV fleets.

## Megawatt Charging Plug Layout



Source: [CharIN e. V. MCS Subgroup, 2022](#)

## 2.1.4 Type of EV Charging station as per their structure

### (a) Batteries Swapping Stations

Battery swapping is a technology and service model in the electric vehicle (EV) industry where depleted batteries are quickly exchanged for fully charged ones at specialized stations, eliminating the need for a lengthy charging process. This approach aims to address some of the challenges associated with EV charging, such as long charging times and limited charging infrastructure.

The most significant issues in battery swapping are the high infrastructure and operational costs. Building and maintaining battery swapping stations can be expensive, making it a challenging business proposition for some companies. Another concern is technical challenges and safety concerns. Battery swapping requires precision engineering, as batteries must be safely and quickly swapped without damaging the vehicle or battery. The high voltage and energy density of EV batteries can also pose risks if not handled correctly. Additionally, consumer adoption and convenience are also setbacks for battery swapping. Drivers may hesitate to use battery swapping if it is not readily available or convenient. In addition, compatibility issues between battery types and EV models may limit the feasibility of battery swapping.



Source: [Tesla's X-Mas Gift: Battery-Swap Stations - TechDrive](#)

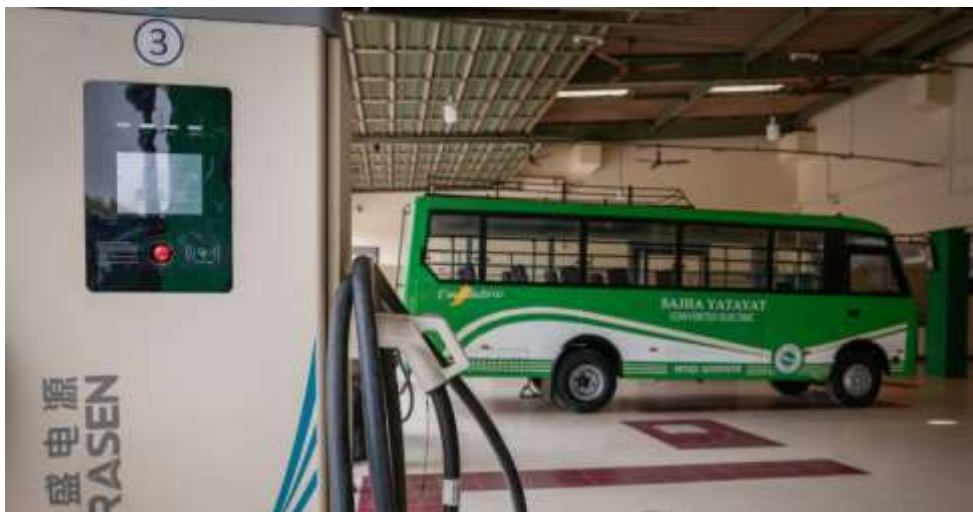


Source: <https://www.gogoro.com/il/enu/gogoro-network/>

**(b) Battery Charging Station (BCS)** shall mean a station where the discharged or partially discharged electric batteries for electric vehicles are electrically recharged



**(c) Captive Charging Station (CCS)** shall mean an electric vehicle charging station exclusively for the electric vehicles owned or under the control of the owner of the charging station e.g., Government Departments, Corporate houses, Bus Depots, charging stations owned by the fleet owners etc. and shall not be used for commercial purpose of charging other vehicles on paid for basis.



**(d) Private Charging Station (PCS)**

This charging station is installed on the private house and compound of a person/institution/company having permit to recharge their own vehicles or vehicles under their authority and battery used in those vehicles, prohibited from taking additional service charge other than the tariff fixed by the Electricity Regulatory Commission (“ERC”)



### (e) Smart Charging Station

Smart charging encompasses a range of functions and capabilities. For private charging, an EVSE with basic functions is adequate for programming according to ToD tariffs. For more advanced solutions at commercial charging facilities or rapid charging hubs, a wider range of functions is needed to enable dynamic load management, respond to ToU tariff signals, and operate different subscription plans for seamless charging transactions.

An EVSE with advanced smart charging capabilities has the following characteristics:

- i) It can be programmed to respond appropriately and autonomously to signals from NEA DCS (e.g. electricity tariff), Central Management System (CMS), etc., to coordinate with ToD and ToU tariffs
- ii) It can be monitored and managed over an app
- iii) It is equipped with GPRS, 4G/5G or wired connection, and is connected to a cloud service
- iv) It shares a data connection with an EV and a charging network
- v) It is compatible with the back-end communication protocol

Source: <https://www.trialog.com/en/electrifying-momentum-ocpp-2-0-1-and-the-unfolding-e-mobility-evolution/>

### (f) Mobile Charging station: -

A mobile electric vehicle (EV) charging station refers to a portable unit that can be deployed to charge electric vehicles wherever needed. Here are some key aspects about mobile EV charging stations:

1. **Portability:** Unlike fixed EV charging stations that are permanently installed at specific locations, mobile EV charging stations can be transported to different locations as needed. This flexibility allows them to be used at events, temporary parking lots, or emergency situations where charging infrastructure may be lacking.

2. **Power Source:** Mobile EV chargers can be powered in various ways, including diesel generators, batteries, or grid connections. Some advanced models may even use renewable energy sources such as solar power.
3. **Types:** They can range from simple units with basic charging capabilities to more sophisticated units that support fast charging (DC fast charging) for quicker turnaround times.
4. **Deployment:** Mobile EV charging stations can be deployed by electric utilities, municipalities, private companies, or even individuals who need to provide charging services in locations where fixed infrastructure is not available or sufficient.
5. **Flexibility:** They contribute to the flexibility and convenience of electric vehicle ownership by reducing range anxiety and enabling EV drivers to charge their vehicles in diverse settings.
6. **Emergency and Event Use:** These stations are particularly useful during emergencies, such as power outages, where they can provide essential charging services. They are also commonly used at events like festivals or conferences where temporary demand for charging infrastructure exists.
7. **Technological Integration:** Modern mobile EV charging stations may feature smart capabilities such as remote monitoring, payment systems, and compatibility with different EV models.
8. **Future Potential:** As electric vehicle adoption continues to grow, the demand for mobile EV charging solutions may increase, especially in areas where infrastructure development is still underway or in rural settings.

Overall, mobile electric vehicle charging stations play a vital role in supporting the expansion and accessibility of electric vehicle charging infrastructure, providing convenient charging options in a variety of scenarios beyond traditional fixed charging locations.



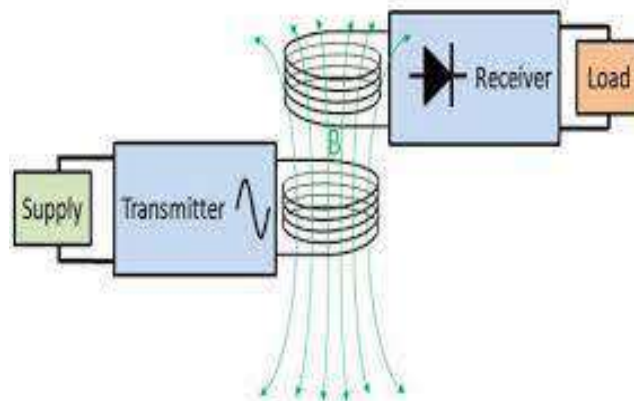
### g) Wireless Electric Vehicle Charging Station (WEVCS):

In wireless charging, power is transmitted via electromagnetic fields from a charging pad to a vehicle, eliminating the need for direct physical connectors. Below is a detailed exploration of this emerging technology from a technical and operational perspective.

**1) Inductive Power Transfer (IPT):** WEVCS operates on the principle of inductive charging, which utilizes electromagnetic fields to transfer power between two coils: a primary coil embedded in the ground or road surface and a secondary coil mounted on the EV. This non-contact energy transfer method works through resonant inductive coupling, which allows efficient energy transmission without the need for direct electrical contacts.

#### System Components:

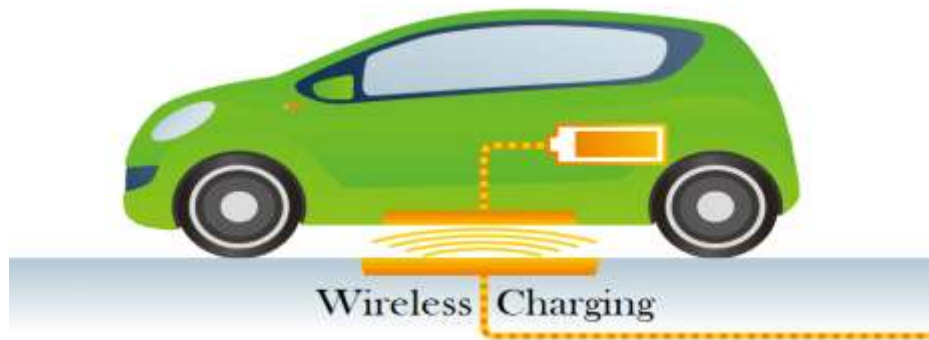
- **Primary Coil (Ground Pad):** Positioned either beneath the parking area or embedded in roadways, this coil is responsible for transmitting electrical energy via electromagnetic fields.
- **Secondary Coil (Vehicle Pad):** Located beneath the EV, this coil receives energy and converts it into direct current (DC) for battery charging.
- **Power Electronics:** These convert the alternating current (AC) from the grid into the appropriate form (AC or DC) for vehicle charging.
- **Control Systems:** Communication between the vehicle and the charging station is managed via a wireless protocol (e.g., Bluetooth, Wi-Fi), ensuring safe and efficient charging by adjusting power levels and alignment.



**Figure 3: Transmitter Receiver Charging Coil**

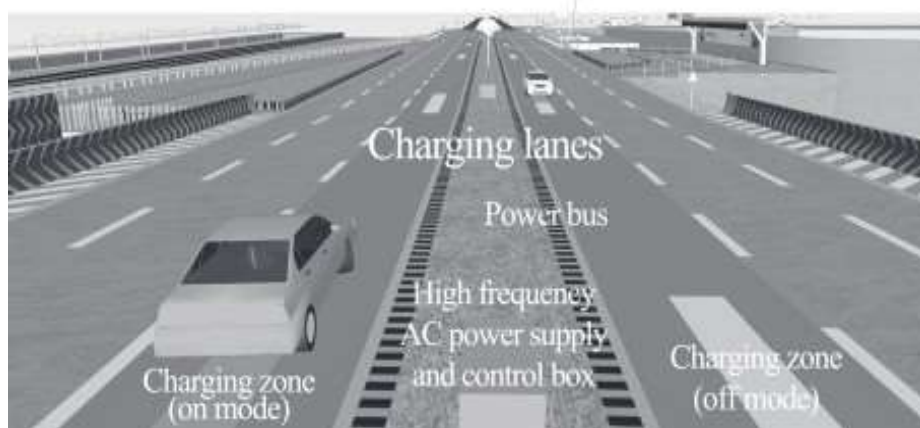
- Model: XKT-412.
- Input Voltage: 12V.
- Output Voltage: 12V.
- Operating Current: 1.2-2 A.
- Receive Coil: 3mm, the receiver output 5V / 1A current
- Transmitter Length  $\times$  Width  $\times$  Height(mm) : 17 \* 12 \* 4
- Receiver Length  $\times$  Width  $\times$  Height(mm) : 24 \* 10 \* 3

**Stationary Charging:** The EV is parked above the primary coil, where the energy transfer occurs through resonant magnetic fields. The alignment of the vehicle with the charging station is typically facilitated by guidance systems (visual or sensor-based).



**2) Resonant Coupling:** The use of resonant inductive coupling maximizes energy transfer efficiency, even with slight misalignment between the coils. This is critical for applications such as in-motion charging, where vehicles may not always be perfectly aligned with the charging station.

**In-Motion Charging:** More advanced systems aim to charge vehicles while in motion, typically embedded within roadways. This requires dynamic load balancing and real-time control of power delivery to accommodate varying speeds, vehicle distances, and misalignments.



### Advantage of WEVCS

- **Convenience:** The elimination of physical connectors offers an easy, hands-free charging experience. This is particularly beneficial in public charging infrastructure, where user experience is a key factor in widespread adoption.
- **Reduced Wear and Tear:** With no physical connectors involved, there is less wear on both vehicle and infrastructure components, reducing maintenance costs.
- **Safety:** Wireless charging systems are inherently safer as there are no exposed connectors or cables that can be damaged or pose a risk, particularly in high-traffic or outdoor environments.
- **Scalability:** WEVCS can be integrated into various environments, from residential areas to highways, with the potential for widespread deployment in smart cities and autonomous vehicle ecosystems

**Table 1: Type of Charger as per their Structure**

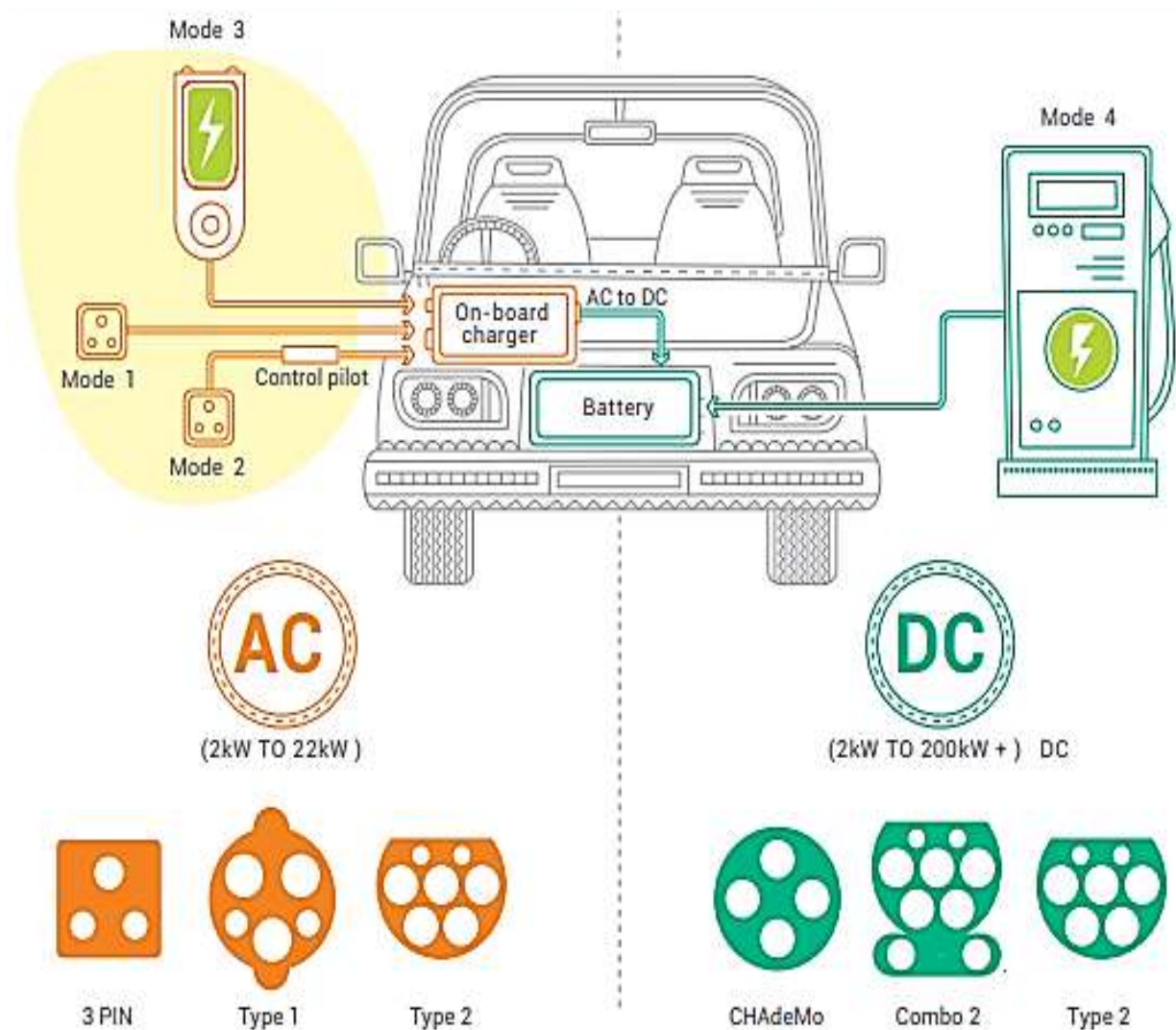
<b>Type</b>	<b>Description</b>	<b>Use Case</b>	<b>Example Setup</b>
1. Wall-Mounted Chargers	Compact AC chargers fixed to walls, typically Level 1 or Level 2	Homes, apartments, offices	Residential garages, parking lots
2. Pole-Mounted / Pedestal Chargers	Standalone chargers on a vertical pole or pedestal, mostly Level 2 or DC	Public spaces, commercial areas	Sidewalks, malls, public parking
3. Fast Charging Cabinets (Standalone or Integrated)	Larger DC fast chargers, with separate power cabinets or all-in-one designs	Highways, fleet depots, inter-city travel	CCS/CHAdEMO/GB/T DC setups
4. Portable Chargers	Mobile chargers that plug into existing power sources	Emergency backup, remote areas	Small units with wheels or hand-carry design
5. Battery Swapping Stations	Instead of charging, batteries are swapped automatically or manually	2W/3W market, logistics fleets	Swapping kiosks with robotic systems
6. Solar-Based Charging Stations	Chargers integrated with solar PV + battery storage	Off-grid, rural areas, eco-friendly deployments	Carports with solar roofs + ESS
7. Gantry-Based Bus Charging (Pantograph)	Overhead conductive arms that charge buses from above	Electric buses at depots or terminals	Inverted or roof-mounted pantograph systems
8. Ultra-Fast Charging Cabinets (Standalone or Integrated)	High-capacity DC chargers (typically 150 kW–500 kW or more), often with liquid-cooled cables, in standalone units or with separate power cabinets	CCS/CHAdEMO/GB/T ultra-fast setups with liquid-cooled connectors, multi-dispenser stations	CCS/CHAdEMO/GB/T ultra-fast setups with liquid-cooled connectors, multi-dispenser stations
9. Megawatt Charging Stations (Future-Ready)	High-power MCS infrastructure for heavy EVs	Electric trucks, freight corridors	MCS (Megawatt Charging System) + large ESS
10. Wireless Charging Station (Inductive Charging) (Future-Ready)	Charging via electromagnetic fields without physical cables; uses inductive coupling between pads	Premium parking, autonomous vehicles, public transport hubs	Embedded ground pads + vehicle receivers, e.g., taxi stands, bus stops

### 2.1.5 Structural Planning Considerations for Nepal

- **Urban Areas:** In Nepal’s urban areas, deploying pole-mounted or wall-mounted AC chargers alongside fast DC charging hubs in public zones is essential to meet the growing demand for convenient and accessible EV charging. This approach optimizes the use of existing infrastructure and supports diverse vehicle types, including two-wheelers and passenger cars.
- **Highways:** Along highways, the installation of fast and ultra-fast DC charging stations equipped with Megawatt Charging System (MCS)-ready capability and backed by energy storage solutions will ensure reliable, rapid charging for long-distance travelers and heavy-duty vehicles. Backup storage enhances service continuity amid grid fluctuations.
- **Remote & Rural Zones:** For remote and rural zones, integrating solar-powered AC/DC charging stations with energy storage is critical to provide dependable and sustainable access to EV charging where grid stability is limited. Modular and scalable designs will accommodate increasing demand while leveraging Nepal’s abundant renewable energy resources.
- **Fleet Depots (Buses/Logistics):** At fleet depots serving buses and logistics vehicles, high-capacity pantograph or cabinet-based megawatt chargers combined with smart scheduling systems will optimize charging efficiency and fleet operations. This infrastructure supports rapid turnaround times and aligns with Nepal’s objectives for electrified public and commercial transport.

Zone	Charging Solution	Key Features & Considerations
Urban Areas	Pole/wall-mounted AC + fast DC hubs	Leverage existing infrastructure, public accessibility, smart grid integration
Highways	Fast/ultra-fast DC, MCS-ready, backup storage	Regular intervals, multi-standard, amenities, energy storage for reliability
Remote & Rural	Solar-integrated AC/DC with storage	Off-grid capability, modular, robust for local needs, sustainable energy
Fleet Depots	Pantograph/cabinet megawatt chargers, scheduling	High-power, automated, smart scheduling, supports large fleets, renewable integration

### 2.1.8 EVCS Charging Method (How it works?)



(Source: NITI Aayog, et. al., Handbook of Electric Vehicle Charging Infrastructure Implementation, 2021)

**Figure 4: EVCS Charging Method and Power Rating**

Four charging modes are distinguished between AC and DC charging: Modes 1-3 correspond to AC charging and Mode 4 to DC charging.

**Mode 1:** It is AC charging. It is used to connect an EV to a conventional socket outlet. It is not advised to use because it is referred to as dumb charging, as it does not allow for any communication between the EV and EVSE and its use is not recommended.

**Mode 2:** It is also called Type-1 AC charging. It is also used to connect an EV to a conventional socket outlet. The portable cable used contains built-in protection and control features which is usually utilized for home charging.

**Mode 3:** It is also called Type-2 AC charging. Better control systems are found in it, which allow for an additional charger to power the EV permitting better communication between the EV and EVSE, and is utilized for public or business charging.

**Mode 4:** It is also called DC fast charging. Better control systems are found in it, which allow for an additional charger to power the EV permitting better communication between the EV and EVSE, and is utilized for public or business charging.

- Different types of chargers provide varying current and voltage levels as per the vehicle-battery requirements. Most vehicles are equipped with a **slow or moderate AC on-board charging** mechanism that can be used to power vehicles directly from a common home plug.
- **DC fast chargers**, on the other hand, deliver direct current to the vehicle battery, bypass the onboard converter, and charge at faster rates. In addition to this, charging infrastructures should also include a level of intelligence that handles user authentication, vehicle communication, data gathering and monitoring, and hassle-free payment.

## 2.1.6 Typical Battery Specifications for Different Segment

VEHICLE SEGMENT	BATTERY CAPACITY	BATTERY VOLTAGE
<b>E-2W</b> 	1.2-3.3 kWh	48-72V
<b>E-3W</b> (passenger/ goods) 	3.6-8 kWh	48-60V
<b>E-cars</b> (1st generation) 	21-60 kWh	72V
<b>E-cars</b> (2nd generation) 	30-80 kWh	350-500V
<b>E-Micro</b> (2nd generation) 	30-70 kWh	350-400V
<b>E-Bus</b> (2nd generation) 	120-350 kWh	600-750V
<b>E-Truck</b> (2nd generation) 	150-350 kWh	600-1000V

Source: [Compiled from market data of available EV models \(as of July 2021\)](#)

### 2.1.7 EV segment and their Battery Capacity and Mileage/ range

EV Segment	Battery Capacity	Voltage	Typical Range	Charging Power Support	Chemistry	Use Case
2-Wheelers	1.5 – 4 kWh	48 – 72V	40 – 100 km	Up to 3 kW (AC)	LFP, NMC, LMO	Personal, delivery (urban)
3-Wheelers (E-rickshaw, Cargo)	3 – 8 kWh	48 – 96V	80 – 120 km	2 – 5 kW (AC or DC)	LFP, Lead-acid (low-cost)	Last-mile transport, light cargo
Passenger Cars (Compact)	30 – 60 kWh	300 – 400V	200 – 400 km	7–22 kW (AC), 50–150 kW (DC)	NMC, LFP	Private vehicles, taxi fleets
SUVs / Premium EVs	70 – 100+ kWh	400 – 800V	350 – 600+ km	Up to 250 kW (DC)	NMC, NCMA	Long-range, performance EVs
Electric Buses	150 – 350 kWh	600 – 750V	150 – 300 km	50 – 350 kW (DC)	LFP (safe, long life)	Public transport, intra-city routes
Electric Trucks	300 – 600+ kWh	600 – 1000V	200 – 500 km	150 kW – 1 MW (MCS-ready)	LFP, NMC	Freight, logistics, long-haul

### Regional Considerations for Nepal

- **Urban & Hilly Terrain:** Higher torque demands → **LFP preferred** for safety and thermal stability.
- **Cold Climate Regions:** Batteries with active thermal management systems are recommended.
- **Heavy EVs (e-buses, e-trucks):** Require megawatt-level charging + depot-based storage support to mitigate grid peaks.
- **Two- & Three-Wheelers:** Cost-sensitive market → battery swapping and modular LFP packs are gaining popularity

## 2.1.8 Electric Vehicles and their Protocols in Nepal

SN	Model	Manufacturer	Country of Origin	Local Partner	Battery Capacity	Motor Capacity	Max. Speed	Range	Charging Standard	
									AC	DC
1	Hyundai Kona EV GL	Hyundai Intl	South Korea	Laxmi International Pvt.Ltd.	39.2 kWh	100 Kw	155 Km/h	305 Km	CCS Charging Standard 7.2 kW Type 2 AC	50 kW CCS-Rapid
2	Hyundai Kona EV GLS	Hyundai Intl	South Korea	Laxmi International Pvt.Ltd.	39.2 kWh	100 kW	155 Km/h	305 Km	CCS Charging Standard 7.2 kW Type 2 AC	50 kW CCS-Rapid
3	Hyundai IONIQ 5	Hyundai Intl	South Korea	Laxmi International Pvt.Ltd.	58.9 kWh	125 kW	165 Km/h	375 Km	CCS Charging Standard 7.2 kW Type 2 AC	50 kW CCS-Rapid
4	Kia Soul EV EX-I	Kia Motors	South Korea	Continental Trading Enterprises Private Limited	64 kWh	81.4 kW	187 Km/h	200 Km	CCS Charging Standard 7.2 kW Type 2 AC	100 kW DC Rapid
5	Kia Niro EV	Kia Motors	South Korea	Continental Trading Enterprises Private Limited	64 kWh	150 Kw	167 Km/h	450 Km	CCS Charging Standard 7.2 kW Type 2 AC	77 kW DC Rapid
6	Mahindra e2o Plus	Mahindra Electric	India	Agni Energy Nepal Group	15.1 kWh	30 kW	80 Km/h	140 Km	CCS Charging Standard 7.2 kW Type 2 AC	
7	MG ZS EV (Standard Range)	MG Motors	UK	Paramount Motors Pvt. Ltd. Nepal	51.1 kWh	130 kW	140 Km/h	319 Km	CCS Charging Standard Type 2-Slow & Fast 7 kW	50 kW CCS-Rapid
8	MG ZS EV (Long Range)	MG Motors	UK	Paramount Motors Pvt. Ltd. Nepal	72.6 kWh	115 kW	175 Km/h	440 Km	CCS Charging Standard Type 2-Slow & Fast 7 kW	50 kW CCS-Rapid
9	Tata Nexon EV XM	Tata Motors	India	Sipradi Trading Pvt. Ltd.	30.2 kWh	95 kW	167 Km/h	312 Km	CCS Charging Standard 3.3 kW slow and 7.4 kW fast 50 kW CCS2	CCS 30 kW DC
10	Tata Nexon EV XZ+	Tata Motors	India	Sipradi Trading Pvt. Ltd.	30.2 kWh	95 kW	167 Km/h	312 Km	CCS Charging Standard 3.3 kW slow and 7.4 kW fast 50 kW CCS2	CCS 30 kW DC
11	Tata Nexon EV XZ+LUX	Tata Motors	India	Sipradi Trading Pvt. Ltd.	30.2 kWh	95 kW	167 Km/h	312 Km	CCS Charging Standard 3.3 kW slow and 7.4 kW fast 50 kW CCS2	CCS 30 kW DC
12	BYD e6	BYD Auto	China	Cimex Inc. Pvt.Ltd.	80 kWh	90 kW	140 Km/h	400 Km	CCS Charging Standard 7.2 kW Type 2 AC	CCS 60 kW DC
13	Dahe DH 350L	Dahe EV	China	Thee Go Group	22 kWh		65 Km/h	120 Km	3kW GB/T Ac charger	N/A
14	Dahe DH 350	Dahe EV	China	Thee Go Group	14 kWh		65 Km/h	150 Km	3kW GB/T Ac charger	N/A

SN	Model	Manufacturer	Country of Origin	Local Partner	Battery Capacity	Motor Capacity	Max. Speed	Range	Charging Standard	
									AC	DC
15	Derry EV7	Henan Derry New Energy Automobiles Co. Ltd.	China	Eco Auto Trading Pvt. Ltd.	17 kWh	15 kW	60 Km/h	158 Km	E kW GB/E AC charger	N/A
16	Derry EM7	Henan Derry New Energy Automobiles Co. Ltd.	China	Eco Auto Trading Pvt. Ltd.	17 kWh	15 kW	60 Km/h	182 Km	Charging Standard	N/A
17	thee Go e8	thee Go	China	Thee Go Group	14.8 kWh	15 kW	100 Km/h	150 Km	3kW GB/T Ac charger	N/A
18	thee Go Danfe	CHTC	China	Thee Go Group	42 kWh	60 kW	100 Km/h	250 Km	6.6 kW GB/T Ac charger	60 kW GB/T DC charger
19	thee Go e6	Joylong	China	Thee Go Group	78 kWh	110 kW	100 Km/h	210 Km	6.6 kW GB/T Ac charger	60 kW GB/T DC charger
21	E-Bus	CHTC-e-BUS	China	Thee Go Group	129 kWh	98 kW	120 Kmph	200 Km	N/A	above 30 kW GB/T DC charger
22	JAC	JAC	China	Thee Go Group	65.3 kWh	110 kW	100 Kmph			above 30 kW GB/T DC charger
23	thee Go Kyta Q-9	Shandong	China	Thee Go Group	11-13 kWh	10 kW	45 Kmph	120 Km	3 kW GB/T Ac charger	N/A

Source: [National Standard Guidelines for Electric Vehicle Charging Stations – Nepal, MoPIT](#)

## 2.1.9 Global Uses of EV Charging Standards

### A. Nepal

As per the Draft Proposed by NEA Bye Law Amendments

**Table 2: EV Charging Standard for Nepal Approved by NEA**

Charger type	Charger connectors	Rated Voltage(Volt)	No. of charging points/ No. of connector guns(CG)
Fast	GB/T (min 20kW)	200-1000	1 / 1 CG
	CHA de MO (min 60kW)	200-1000	1 / 2 CG
	Type-2 AC (min 22kW)	360-480	1 / 1 CG
	GB/T (Min 60 kW)	200-750	1 / 2 CG
	CCS 2.0 (Min 60 kW)	200 - 750	1 / 1 CG
Slow/ Moderate	GB/T AC (min 7kw)	220	1 / 1 CG
	Type-2 AC (min 7kW)	220	1 / 1 CG
	Plug in charger 3.3 kW each	220	1 / 3 CG

**Table 3: EV Charger operated by Private sector institutions and their location**

Name of the Company/ Brand	Charger Type/ Size	Location
TATA	CCS-2/30 KW	Bagdole, Chumlinta, Dharke, Pokhara, Narayanghat, Hetauda, Itahari, Dhalkewar, Mulkot, Bhairahawa
Sundar Yatayat	180 KW, 40 KW GB/T 40 KW GB/T	Kathmandu Butwal (Upgrading to 180 KW)
Dee-Go Group	GB/T 90 KW GB/T 30 KW 7 KW AC-Type 2	Mulkot Kurintar, Bardibas, Pepsikola, Kathmandu Mulkot
MG Motors	7 KW AC-Type 2 30 KW CCS-2	Various 12 Location of the country Kurintar and Komal Hotel, Dhalkewar
Hyundai	7 KW AC-Type 2	Various 15 Locations of the country
BYD	40 KW/AC Type-2 CCS Type -2	Various 20 Locations of the country

[Source: Online data of the respective company's site and newspaper](#)

**B. India**

As per Model Building Bye-Laws (MBBL – 2016) for Electric Vehicle Charging Infrastructure

**Table 4: EV Charging Standard for India**

Charger Type	Charger Connectors*	Rated Voltage (Volt)	No. of Charging Points/No. of Connector guns (CG)
Fast	CCS (min 50 kW)	200-1000	1/1 CG
	CHA de MO (min 50 kW)	200-1000	1/1 CG
	Type-2 AC (min 22 kW)	380-480	1/1 CG
Slow/Moderate	Bharat DC-001 (15 kW)	72-200	1/1 CG
	Bharat DC-001 (10 kW)	230	3/3 CG of 3.3 kW each
*In addition, any other fast/slow/moderate charger as approved BIS standards whenever notified			

Source: Page 13 of 40 of  
[https://mohua.gov.in/upload/whatsnew/5c6e472b20d0aGuidelines%20\(EVCI\).pdf](https://mohua.gov.in/upload/whatsnew/5c6e472b20d0aGuidelines%20(EVCI).pdf)

**2.1.10 Different Vehicle segment with technical parameters and their EV penetration in Nepal to date.**

Vehicle Type	Brand	Model	Peak Power	Peak/ Rated Power	Battery	Number of EVs	Share of Public Charger (25% Utilization)	Standard Type of EV Connector
Scooter		Lithino 2.0 LI		250W	60V 26Ah	23,213	10%	Type 2 (16A) CCS Charging Standard 3.3 kW Type 2 AC and GB/T
Scooter		S-Way		2000W	72V 32Ah			
Scooter		KN-Beyond		3000W	72V 40Ah			
Scooter	Aima	X612	4100W	3000W	60V 35Ah*2			
Motorcycle		Komaki Ranger	4800W	4000W	72V 50Ah			
Motorcycle		Miku SUPER	5600W	3000W	72V 20Ah			
Motorcycle		DIFO		8000W	72V 80Ah			
Rickshaw		FT-3	1200W	1000W	60V 160Ah	40,356	20%	CCS Charging Standard 7.2 kW Type 2 AC
Rickshaw		RAGE+	9.55kW	6.04kW	210Ah			
Rickshaw		Tricycle		1000W	48V			
Cargo Rickshaw		Smart Urban Cargo E-Cart	2500W	1520W	48V 90Ah			
Rickshaw		Jaiswal		1300W	100Ah			
Car		FH772150LV7		7.5kW	150Ah	12,300	35%  Within 35% share, Type-2 AC (30%) and DCFC (70%)	CCS Charging Standard 7.2 kW Type 2 AC  CCS Charging Standard 7.2 kW Type 2 AC  CCS Charging Standard 7.2 kW Type 2 AC  CCS, GB/T  CCS Rapid
Car		FH772150LV7		7.5kW	234Ah			
Car		G-X8	15kW	7.5kW	7.5kWh 100Ah			
Mini Van		X30LEV	60kW	30kW	334.88V 41.86kWh			
Car	Neta	Neta V	70kW	30kW	350.4V 72kWh			
Car	Hyundai	IONIQ5	160kW	53kW	653V 111.2Ah			

Vehicle Type	Brand	Model	Peak Power	Peak/ Rated Power	Battery	Number of EVs	Share of Public Charger (25% Utilization)	Standard Type of EV Connector
Car	e VERITO	D6		30.5kW				
Car	e VERITO	D6		30.5kW				
Car	Tesla	Tesla Model 3 Standard Range		174kW	350V			
Car	Tesla	Tesla Model 3 Long Range AWD		293kW				
Car	KIA	Niro	150kW	29kW	336V 180Ah			CCS
Car	Tesla	Tesla X Long Range 100D	386kW		100kWh			
Pick Up	Jac	HFC1037D4EV1	150kW	70kW	345.6V 65.3kWh			
Mini Van	BYD	T3	100kW	35kW	50.3kWh			CCS 60 kW DC
Van		E-Supro		23kW	-			
Micro Bus		EC36		30kW	42kWh 125Ah	5,239	90%	
Bus		CHTC KINWIN		92kW	614.4V 210Ah	895		GB/T
Bus		HKL6600RBEV11		60kW	346.6V 226Ah			GB/T

Source:

1. Transport Management Department, 2080 BS; (Vehicle Type, Brand, Model, Peak/Rated Power, Battery Size)
2. Department of Custom, Nepal; (Number of EVs imported)
3. Handbook of NITI Aayog of India, 2021 (Share of Public Charger)

### 2.1.11. Selection Criteria of EV Charger for EV PCI/Station.

Vehicle segments and their standard type of connector use

(1) Peak/ Rated Power (kW)

(2) Share of Public Charging Station

(3) Number of EVs penetration in NHW

## (4) Availability of EV segment in Nepalese Market (China/India Manufacturer)

**2.1.12. Selection of different type of EV charger for different EV segment.**

SN	EV Segment	Type of EV Charger	Connector and their guns	Number of EV Charger per Charging Station		
				Category-I	Category-II	Category-III
1	e-2Ws	3.3 kW, 16A, 230V	Type1,2 AC (1/2 CG)	4	4	4
2	e-3Ws	7.4 kW, 32A, 230V	2 AC (1/2 CG)	4	0	0
3	e-4Ws	22 kW, 380-480V	Type 2 AC (1/2 CG)	1	0	0
4	e-4Ws	60 kW, 200-750V, DCFC	GB/T (1/2 CG)	2	2	1
5	e-4Ws	60 kW, 200-750V, DCFC	CCS-2 (1/2 CG)	1	1	2
6	e-4Ws (Car/Bus/Truck)	120 kW, 200-1000V, DCFC	GB/T (1/2 CG)	1	0	0
Total				13	7	7

Note:

Category-I:

Terrain Areas & Mixed Fleets

Tailored for rugged landscapes and diverse vehicle ecosystems. Offers multi-standard compatibility (AC/DC) with extended dwell times, ideal for SUVs, adventure vehicles, and mixed EV fleets requiring flexible charging windows.

Category-II:

Mountainous & Hilly Regions

Precision-engineered for 4-wheelers with dynamic load balancing. Features high-speed DC chargers (50-1kW) and smart grid integration, prioritizing swift turnaround without compromising mountainous grid stability.

Category-III:

Urban Centers & Transit Routes

High-density rapid-charging nodes for commercial fleets and private vehicles. Incorporates queue management systems and battery preconditioning for sub-15min charge cycles, maximizing urban space utilization.

## 2.2 GUIDELINE, STANDARD, REGULATION AND SPECIFICATION OF EVPCI

### 2.2.1 NEA, Electricity Distribution Regulation-2078, Chapter 3, EVCS and their Tariff

Construction and operation policies of electric vehicle charging infrastructure are as follows:

- Permission will be given to install charging stations in private residence, offices, and firm/ company/ institutions.
- Permission will be given to entity/ firm/ individual/ company (approved form Government of Nepal) to install public charging station in public places and private land.

Each public charging station should have following minimum infrastructures:

- 11,000/400 or 33,000/400 substation transformer, line, cable, termination, metering unit including all safety equipment.
- Vehicle parking, area for charging and related civil structures.
- Ample for entry, charging and exit of vehicle.
- If sufficient space is available at public charging stations, stand-alone battery swapping facilities can also be added in addition to the specified mandatory facilities.

At least one of the following types of chargers must be connected as shown in Table 4: EV Charging Standard for India.

*\* In addition, any other fast/slow/moderate charger as per approved NEA standards whenever notified*

Special arrangements regarding public charging stations:

- After implementation of this system, Nepal Electricity Authority will provide electricity service with transformer to service providers who install charging stations with electricity demand upto 200 kVA. In the case of charging stations with higher demand than that, the Nepal Electricity Authority will do the necessary installation work, but the rest of the work, including transformer connection, will have to be done by the charging service provider.
- The charging station operator can add 20% on the base price fixed by NEA as the retail price.
- The charging station operation modality is under preparation. Currently, it can be operated by the smart meter/ TOD meter provided by NEA.

### NEA, Electricity Tariff Regulation- 2078

#### 3. Time of Day (ToD) Tariff Rate

##### 3.1 Tariff Rate from Baishakh to Mangsir

Consumer Category	Demand Charge Nrs./ KVA/ month	Peak Time (17.00-23.00)	Off Peak Time (23.00-5.00)	Normal time (5.00-17.00)
B. Medium Voltage (33 KV)				
Transportation				

Consumer Category	Demand Charge Nrs./ KVA/ month	Peak Time (17.00-23.00)	Off Peak Time (23.00-5.00)	Normal time (5.00-17.00)
a) Public Transportation (Charging)	230	7	3.7	5.5
3.2 Tariff Rate from Paush to Chaitra				
Consumer Category	Demand Charge Nrs./ KVA/ month	Peak Time (17.00-23.00)	Normal time (5.00-17.00)	
B. Medium Voltage (33 KV)				
Transportation				
a) Public Transportation (Charging)	230	7	5.5	
3.3 Transportation for Automatic Swap Card Users without Demand Charge				
3.3.1 Public Transportation (Charging Station)				
Description	Energy Charge Nrs./kWh			
	Peak Time (17.00-23.00)	Off Peak Time (23.00-5.00)	Normal Time (5.00-17.00)	
Tariff Rate from Baisakh to Mangsir				
Medium Voltage (33 kV)	8.4	4.45	6.6	
Medium Voltage (11 kV)	8.6	5.05	6.7	
Low Voltage (230/400 V)	8.7	5.05	6.9	
Tariff Rate from Paush to Chaitra				
Description	Peak Time (17.00-23.00)	Normal Time (23.00-17.00)		
Medium Voltage (33 kV)	8.4	6.6		
Medium Voltage (11 kV)	8.6	6.7		
Low Voltage (230/400 V)	8.7	6.9		

### 2.2.2 Guidelines and Standards for Charging Infrastructures for EV, the revised version, 2022, Ministry of Power, India

As per the Guidelines and Standards,

- Owners may charge their Electric Vehicles at their residence/offices using their existing electricity connections.
- Any individual/entity is free to set up public charging stations provided that, such stations meet the technical, safety as well as performance standards and protocols laid down below as well as norms/standards/specifications laid down by Ministry of Power, Bureau of Energy Efficiency (BEE) and Central Electricity Authority (CEA) from time to time.

Every Public Charging Station (PCS) will comply with the following: -

- An exclusive transformer with all related substation equipment including safety appliance, if required by Supply Code as approved by Appropriate Electricity Regulatory Commission
- Appropriate civil works
- Appropriate cabling & electrical works ensuring safety
- Adequate space for Charging and entry/exit of vehicles
- Appropriate Fire protection equipment and facilities
- PCS shall have, any one or more chargers or any combination of chargers from the table given in the Standards in more or more electric kiosk/boards
- Tie up with at least one online Network Service Provider (NSPs) to enable remote/online booking of charging slots by EV owners
- Public Charging Station may also be installed by Housing societies, Malls, Office Complexes, Restaurants, Hotel, etc. with a provision to allow charging of visitor's vehicles which are permitted to come in its premises
- For long range EVs and/or heavy duty EV (like trucks, buses etc.), at least two chargers of minimum 100 kW (200-750V or higher) each of different specification (CCS/CHAdeMO Chargers for above capacity or BIS Standards for eBus Charging Station as provided by the Standards

### **Locations:**

- At least one Charging Station shall be available in a grid of 3 Km X 3 Km. Further, one Charging Station shall be set up at every 25 Km on both sides of highways/roads. For long range EVs, there shall be at least one Fast Charging Station with Charging Infrastructure at every 100 Km.
- The appropriate Government (Central/State/Local) may also give priority to existing retail outlets (ROs) of Oil Marketing Companies for installation of PCS (in compliance with safety norms).

### **2.2.3 Electric Vehicle Charging Guideline, 2022, Bangladesh**

The Electric Vehicle Charging Guideline issued from Energy Efficiency and Conservation Section of Ministry of Power, Energy, and Mineral Resources in Bangladesh, aims to safe, reliable, accessible, and affordable charging infrastructure to facilitate the extensive use of electric vehicles and reduce fossil fuel dependency, which could establish a structural framework regarding installation of charging infrastructures attracting private entrepreneurs and bringing the system under a regulatory regime. Some of the key features regarding the Guidelines are:

- Charging infrastructure installed at government organizations, housing associations, shopping malls, office buildings, restaurants, hotels, petrol pumps, etc., aiming to be used by more than three users or user groups shall be considered as Public Charging Stations.

- To charge Four-Wheeler-Electric-Vehicles, chargers composed of either one or more of the following chargers in the public charging stations can be used in the primary phase.

**Table 5: Four Wheeler EV Charger Types as per Bangladesh Guidelines**

Charger Type	Charger Connectors	Minimum Rated Power
DC Charger	Combined Charging System	50 kW
	CHAdeMO	50 kW
AC Charger	Type-2 AC	11 kW

### 2.2.3.1 Regulations for Installation and Operation of EV Charging Stations

#### 1. Application of Filling Station Regulations:

- If a charging station is installed within the premises of a Filling, CNG, Diesel, Petrol, Octane, or LPG station, the existing regulations applicable to that filling station shall also apply to the charging station.

#### 2. Minimum Distance between Charging Stations:

- Within district towns and city corporation areas: A minimum distance of 2 (Two) kilometers must be maintained between charging stations on the same side of the road.
- In other areas (outside city corporations): A minimum distance of 4 (Four) kilometers must be maintained.
- Relaxation Provision: The government may under special circumstances relax these minimum distance requirements as necessary.

#### 3. Compliance with Existing Laws:

- Installation of charging stations must strictly comply with all prevailing rules, regulations, and technical standards applicable at the time of setup.

#### 4. Land and Access Requirements:

- The Charging Point Operator (CPO) shall:
- Arrange and secure the required land for the charging station.
- Ensure provision of a dedicated entry and exit driveway to the charging station.
- Obtain all necessary business licenses and approvals from relevant regulatory and governmental authorities.

#### 5. Basic Amenities at Charging Stations:

- Charging stations must be equipped with the following facilities within their compound:
- Continuous telephone and/or mobile network connectivity.
- Provision of clean drinking water.
- Modern, hygienic toilet facilities for both men and women.

#### 6. Elevation and Drainage Requirements:

- The compound of the charging station must be constructed at a higher elevation than the adjacent road to ensure effective water drainage and prevent flooding.

#### 7. Lighting and Decoration Standards:

- Charging stations must avoid excessive decorative lighting that causes over-illumination or light pollution.
- Exception: These lighting and decoration conditions shall not apply to charging stations installed within the courtyard of a filling station where the required amenities (water, toilets, etc.) are already available.

#### **2.2.4. Safety aspects of EV Charging Stations**

Safety aspects of EV Charging Stations as per Nepal Electricity Authority Guideline and Bidding Document for SASEC Power Transmission and Distribution System Strengthening Project

- Unsafe charging mode such as manual charging should not be performed;
- The system must have following protections at the minimum: AC input over/under voltage protection, DC output over/under voltage protection, setting DC output voltage limiting/ current limiting value, overvoltage and overcurrent protection, short circuit protection, AC lightning protection, overheat protection, battery reverse connection, limit Protection functions such as pressure limiting current protection, accidental extraction of guns, lightning protection, insulation monitoring, bleeder circuit, power supply loop contactor adhesion monitoring, and charging gun temperature protection;
- The charger should have an emergency stop device which is visible and easily accessible and measures to prevent mal-operation, which is used to cut off the connection between the power supply equipment and the electric vehicle to prevent electric shock, fire or explosion;
- The charging gun should have a temperature detection function;
- The charger should have a bleed function. After fault detection, the charging output voltage shall be vented to avoid voltage shock to the battery load during the charging phase.
- The charger should have an insulation monitoring function. When the charging gun interface is connected, the charger should be responsible for the insulation monitoring inside the charger (including the charging cable) before charging starts. An alarm should be created, and charging stopped when the insulation resistance crosses standard limit;
- The charger should have the function of monitoring and alarming the power circuit contactor.
- Protection against overvoltage at the battery: The D.C. EV charging point shall disconnect supply of electricity to prevent overvoltage at the battery, if output voltage exceeds maximum voltage limit sent by the vehicle.

**Locking of coupler:** A vehicle connector used for DC charging shall be locked on a vehicle inlet if the voltage is higher than 60 V DC. The vehicle connector shall not be unlocked (if the locking mechanism is engaged) when hazardous voltage is detected through charging process including after the end of charging. In case of charging system malfunction, a means for safe disconnection may be provided

**Disconnection of EV:** One second after having disconnected the EV from the supply (mains), the voltage between accessible conductive parts or any accessible conductive part and earth shall be less than or equal to 42.4 V peak (30 V rms) , or 60 V D.C., and the stored energy available shall be less than 20 J (as per IEC 60950). If the voltage is greater than 42.4 V peak (30 V rms) or 60 V D.C., or the energy is 20 J or more, a warning label shall be attached in an appropriate position on the charging stations

**Verification of Vehicle Connector Voltage:** The EV Charging station shall not energize the charging cable when the vehicle connector is unlocked. The voltage at which the vehicle connector unlocks shall be lower than 60 V.

### 2.2.5 Safety Standards for Battery Chargers

When it comes to battery charger safety, there are several standards that need to be followed to ensure safe charging. These standards are designed to protect both the user and the battery itself. Here are some important safety standards for battery chargers:

- **Ventilation:** Proper ventilation is crucial during battery charging to prevent the accumulation of potentially explosive gases. Charging batteries can produce hydrogen gas, which can be highly flammable. Ensure that the charging area is well-ventilated to minimize the risk of gas explosions.
- **Avoid Sparks:** Sparks can ignite the hydrogen gas produced during battery charging, leading to a potential explosion. It is important to avoid any sparks or open flames near the charging area. This includes refraining from smoking or using any flammable materials in the vicinity.
- **Terminal Safety:** When connecting the battery to the charger, ensure that the terminals are properly aligned and securely connected. Loose connections can lead to overheating, which can be dangerous. Always follow the manufacturer 's instructions for proper terminal connections.
- **Proper Use and Discharge:** It is essential to use the battery charger as intended and avoid overcharging or undercharging the battery. Overcharging can lead to overheating and damage the battery, while undercharging can result in reduced battery performance. Follow the recommended charging times and discharge the battery properly before recharging.

### 2.2.6 Importance of Safe Work Procedures in Battery Charging

Following safe work procedures in battery charging is crucial for

- **Preventing Accidents:** Safe work procedures help minimize the risk of accidents and injuries during the battery charging process. By following guidelines such as proper

ventilation and handling batteries with care, you can reduce the chances of explosions, fires, or chemical burns.

- **Protecting Equipment:** Using battery chargers incorrectly can damage both the charger and the batteries. By following safe work procedures, you can ensure that the charger is used properly, prolonging its lifespan. Additionally, proper handling and charging techniques can help preserve the battery's capacity and overall performance.
- **Avoiding Environmental Hazards:** Improper battery charging practices can have negative environmental impacts. For example, overcharging batteries can lead to the release of harmful chemicals into the environment. By following safe work procedures, you can minimize these risks and contribute to a cleaner and safer environment.
- **Fire safety:** As the EV charging stations use high power electrical equipment, they are very prone to fire hazards. So, the space plan of an EV charging station must have proper fire alarm system along with fire hydrant systems. It is recommended to keep a fire extinguisher near to every charger. Furthermore, the site for the charging station must not be near place which uses highly inflammable materials.

#### **2.2.7 Safety Standards in Electric Vehicle Charging Guideline, 2022, Bangladesh**

- As per the general conditions of standards and safety-related matters of the Guideline, some of the key elements it includes are:
- All electric vehicle-charging stations shall be provided with protection against the overload of input and output supply fittings.
- The electric vehicle parking place shall be such that the distance between the electric vehicle charging point and the electric vehicle shall be within 05 meters.
- Electric vehicle charging stations shall be equipped with a protective device against the uncontrolled reverse power flow from the electric vehicles.
- In the case of Direct Current (DC) electric vehicle charging, the charging point may disconnect the electricity supply automatically to prevent overvoltage at the battery if the output voltage exceeds the maximum voltage limit sent by the vehicle.
- Electric vehicle connections in the charging station shall be installed in a way to avoid, as far as practicable, the existing network's unbalance related problems.
- All electric vehicle charging stations shall be equipped with a sub-circuit protected by a voltage-independent residual current device and provide personal protection compatible with electric vehicles' charging supply.
- The cable may be fitted with an earth-connected metal shielding, and the cable insulation shall be wear-resistant and maintain flexibility over the entire temperature range.

#### **2.2.8 Some International Safety Standards regarding Charging Devices and Charging Stations**

- IEC. 2005a. Low voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock, IEC 60364-4-41. International Electrotechnical Commissions

- IEC. 2005b. Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems, IEC 62061. International Electrotechnical Commission
- IEC. 2014. Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 1: General requirements, IEC 62196-1. International Electrotechnical Commission.
- IEC 61851-23:2014: Electric vehicle conductive charging system - Part 23: DC electric vehicle charging station
- IEC 61851-1:2017: Electric vehicle conductive charging system - Part 1: General requirements
- IEC. 2016. Plugs, socket-outlets, vehicle connectors and vehicle inlets – Conductive charging of electric vehicles – Part 2: Part 2: Dimensional compatibility and interchangeability requirements for AC pin and contact-tube accessories, IEC 62196-2. International Electrotechnical Commission.
- ISO. 2010. Safety of machinery - General principles for design - Risk assessment and risk reduction (ISO 12100:2010), ISO 12100. International Organization for Standardization.
- ISO. 2019. Road vehicles — Vehicle to grid communication interface — Part 1: General information and use-case definition, ISO 15118-1. International Organization for Standardization.
- ISO. 2020. Electrically propelled road vehicles — Conductive power transfer — Safety requirements, ISO 17409. International Organization for Standardization

### 2.3 PRODUCTS TO BE USED IN EV PCI

Some Products to be used in EV PCI considering the interoperability of the device and the companies responsible for it:

Location	Company/ Network	Product/ Service Focus	Interoperability/ Quality	Notes
INDIA	Rimone Charge	AC & DC fast chargers	Multi-connector support (e.g., CCS, Bharat standards)	MoU with BHEL, charging plazas for e-buses/cars
	Exicom	DC chargers (50kW, 120kW)	Supports Tata, Mahindra, CCS, Bharat AC/DC	Won NTPC tender, broad OEM compatibility
	Plugzmart	AC chargers (3.3–22kW)	CPRI (NABL), ARAI certified	In-house development, certified for Indian market
	Amara Raja	EVSE (AC/DC chargers)	OEM, supports various vehicle types	Integrated with Hero Electric for last-mile delivery
	EVRE	AC Type 2 chargers (22kW)	App-based management, multi-client support	Charging hubs for fleets, workplace solutions
	Evotpoint	AC (3.3–22kW), DC (25–180kW)	Franchise model, supports	Highway and shared parking installations

Location	Company/ Network	Product/ Service Focus	Interoperability/ Quality	Notes
			residential/commercial use	
CHINA	ZECONEX	Smart, efficient chargers	Advanced tech, quality management	Full pre/post-sales support, high customization
	Nanjing SIPO Technology	Wide range of EV chargers	ISO9001, multiple patents	OEM for major Chinese EV brands
	Wuxi Sanshi Electronics	Lithium-ion battery chargers	Certified for export, safety norms	Supplies to top Chinese and export markets
AMERICAN	Tesla	Superchargers, Wall Connectors	Proprietary & CCS compatibility	Dominant in US, Model Y/3 most sold EVs
	ChargePoint	AC/DC charging stations	Open standards (CCS, CHAdeMO, J1772)	Largest network, high reliability
	Electrify America	Ultra-fast DC chargers (up to 350kW)	Open standards (CCS, CHAdeMO)	Largest open DC fast-charging in US, renewable energy
	Blink Charging	Networked AC/DC stations	Supports multiple connector types	Cloud-based management, global presence
	EVgo	Fast chargers (urban focus)	CCS, CHAdeMO, Tesla (adapters)	High uptime, urban and highway locations

## 2.4 ASSESSMENT OF THE CAPACITY OF THE DISTRIBUTION NETWORK TO SUPPLY THE LOAD OF THE EV

The EVCS selected location-wise assessment of capacity of the distribution network to supply the load of the EVCS will be assessed/reviewed using the national/international paper and their methods after following data collection as per field visit schedule.

**Table 6: EVSC locationwise Assessment of 33kV and 11kV Distribution Line**

Selected location of EVCS					33/11 kV SS										
S.N.	Province	Municipality/ Rural Municipality	Ward Number	Place Name	SS Name	Power Transformer MVA	Feeder Name	Feeder Capacity (MVA)	Supply Voltage (kV)	Load		Power Factor		Frequency (Hz)	Harmonic Distortion
										Normal Time	Peak Time	Normal Time	Peak Time		

## 2.5 ASSESSMENT OF THE STABILITY AND ADEQUACY OF THE EXISTING POWER SOURCE CONNECTING THE CHARGING STATION TO THE GRID

### Method/Calculation of power demand of EV-by-EV Segment

#### Method 1

STEP A: Arrive at the daily kilometers driven by each vehicle segment, based on transport planning data or data from city development plans.

STEP B: Based on average battery capacity and driving range of each vehicle segment, calculate the daily energy requirement for EV charging.

#### Charging Demand by Vehicle Segment

Vehicle Segments	Daily kms driven	Battery capacity in kWh	Driving range in km/full charge	Daily charging demand in kWh	Total daily charging demand in kWh - 2025	Total daily charging demand in kWh - 2030
E-2W	40	2.5	80	1.25	1,25,596	7,65,442
E-3W (passenger/ cargo)	120	7	100	8.4	2,55,162	9,72,757
E-car (personal)	40	30.2	312	4	17,498	1,64,786
E-car (commercial)	100	21.2	181	12	55,931	4,91,838

Source: NITI Aayog Handbook, 2021, India

#### Method 2

Demand/Capacity of Distribution Line/selected EV Charging Station = p

For example, Lets Assume, Number of Selected Charging Station = q = 204

Location-wise Capacity of Charging Station = r = 250 kW

where, AC Type 2 = 22kW

DC/FC = 60kW X 4 nos & 120 kw\*1 no.

Then, p = Number of Selected Charging Station (q) X Capacity of Charging Station (r)

= 400 X 204 = 81600 kW=81.MW /day

Load for EVSC per day

As per NEA Annual Report 2024, Availability of peak load = 2500

Load for EVSC per day = 81.6/2500 = 0.03

## 2.6 GRID IMPACT STUDY OF THE HEAVY VEHICLE

Grid Impact Study of heavy vehicle integration is required since they need extremely fast charging that result in very high charging load (at the multiple Megawatt scale), if many such vehicle charge simultaneously.

**Table 7: EVSC locationwise Assessment of 33/11kV Substation Capacity**

Selected location of EVCS					Existing Distribution Line				Reinforcement/ New Proposed Distribution Line	
S.N.	Province	Municipality/ Rural Municipality	Ward Number	Place Name	33kV or 11kV	Feeder Load (kA)	Conductor Size	Line/ Length (km)	Conductor Size	Line/ Length (km)

### Causes of Harmonic Distortion to the Grid

The device which produces harmonic distortion in the power system/grid are:

- a) EV chargers
- b) Power electronics equipment VFDs (Variable Frequency Device)
- c) Electronically Commuted (EC) Motors
- d) Rectifiers
- e) Computers
- f) LED Lights
- g) Arcing devices (welder, arcfurnaces, fluorescent light)
- h) Iron saturating device (transformer)

Harmonics are the result of nonlinear load that convert AC line voltage to DC. Harmonics show in to the Electric system because of nonlinear electronics switching devices, such as Variable Frequency Drives (VFDs), Computer Power Supplies and energy efficient lighting, distribution power cable, motors or drives to overheat.

### 2.6.1 Impact of EV integration to grid

- A. Comprehensive Review Based on the Impact of Integrating Electric Vehicle and Renewable Energy Sources to the Grid by Pampa Sinha, Kaushik Paul, Sanchari Deb, and Sulabh Sachan

**Table 8: Impact of EV integration to grid**

Parameter	Diligence
Peak load	ToU rates reduced the peak load by 5%
Harmonics	Active compensation based harmonic reduction technique that reduced the EV charging induced harmonic distortion in current from 4.88% to 4.03%

<b>Parameter</b>	<b>Diligence</b>
Voltage profile, Transformer loading	Impact of uncontrolled, smart, and V2G strategy on a residential power distribution network of Netherland
Residential load demand	Empirical estimation of the grid impact due to in-home EV charging was different from that predicted by existing simulation models due to factors such as consumer behaviors
Harmonics, Voltage profile	With 1 EV, 20.30% of THD is produced, and with 3 EVs, 27.67% of THD is produced. Low voltage is also observed when more than one EV charger is connected at one phase
Load demand, power losses, voltage profile	Innovative model to generate the profiles of EV charging demand and investigate the impact of charging on grid
Reward due to discharging	Bottleneck model considering tradeoff between waiting time cost and reward due to discharging
Tariff, Peak power, carbon footprint	By adopting smart charging at home the EV evening peak load can be reduced by 30% to 50%. Further, a 10% decrease in carbon footprint is achieved by valley-filling with work charging
Voltage profile, harmonics, stability, power quality	EVs were modelled as mobile loads and was used as flexible resources
Transformer loading, Power factor, phase asymmetry, voltage profile	Modelled the impact of EV charger on LV residential network. Generally, nonlinear EV loads are connected to different phases, so there will be a phase asymmetry in the network. This asymmetry can be reduced by proper grid planning. Turning on and off of EV charger may impact the power factor that can be tackled by reactive power compensation
Voltage profile, power quality	Placing the EV load on weak points of the power distribution network and uncoordinated charging may be detrimental to smooth operation of the grid
Voltage profile, transformer loading, congestion	Overloading of lines and transformers would take place when the share of EVs is above 20% for Norwegian grid
Load demand, frequency deviation	Self-learning PSO based optimal EVs charging power control strategy considering the net charging power demand and frequency deviation to ensure smooth functioning of the grid
Harmonics, thermal limit, peak load	The voltage profile of the buses of the distribution network of Qatar was examined as the EV load increased to determine the capacity of the buses at certain THD levels
Voltage sag, load demand, power quality	Residential grid voltage sag increased by about 1.96% to 1.77%, 2.21%, 1.96 to 1.521% and 1.93% in four EV-charging profiles, respectively
Peak load, charging frequency	An open-access agent-based EV simulation model was proposed including a probabilistic plug-in decision module

Parameter	Diligence
	developed and calibrated to match the charging behavior observed in the Electric Nation project
Reliability	Simulated results showed that compared to the non-dynamic charging mode, the electric bus dynamic charging mode does not cause additional deterioration to the reliability indices such as SAIFI, SAIDI, and AENS
Peak load, line loading	Coordinated charging strategy for the EVs considering their dynamic behavior
Transformer loading	Predicted the future EV charging demand of an office complex in order to estimate the flexibility potential of EVs
Power quality, voltage profile, cable loading	Simulations showed that in urban networks EV integration would cause higher cable loading and in rural networks it would cause voltage drops
Power quality	Comparative analysis of how common DC and AC bus architectures of fast chargers would impact the power quality of the grid
Voltage profile, power quality	Compared different charging strategies and ranked smart charging highly to tackle the adverse impact of EV charging on grid
Voltage stability, reliability, power losses	Novel approach for charger placement considering cost, accessibility index, and VRP index
Peak load, voltage profile	Modelled the impact of EV charger on a Latin American grid and concluded that with 10% EV penetration the operational parameters of the grid would be least affected
Voltage profile, peak load	Simulations showed that the weakest power cable in the system would experience overload at a 20% EV penetration level. The network tolerated an EV penetration of 50% with regard to the voltage levels at all end-users
Voltage stability, reliability, power losses	Multi-objective formulation of the charger placement problem considering cost, reliability, power
Peak load	Stochastic bottom-up approach to analyze how EV charging would affect the load profiles
Voltage stability, reliability, power loss	System could sustain placement of fast charging stations at the strong buses up to a certain level, but the placement of fast charging stations at the weak buses of the system hampers the smooth operation of the power system
Voltage profile	The lowest increased value of EV charging load had an effect on the load voltage deviation (0.062), the total active power loss (120 kW) and the total reactive power loss (80 kVAr), respectively

Parameter	Diligence
Peak load	Proposed a multi-agent system to simulate the interaction of EVs in energy hub with different penetration rates and charging pattern
Voltage profile, peak load	Smart charging strategies are beneficial and could contribute to less voltage violations and cost savings
Reliability	After placement of fast charging station with 30 servers at bus 11 which was the strongest bus of the system the SAIFI increased to 0.1080 interruption/yr. SAIDI and CAIDI value also increased to 0.5374 h/yr and 5.2481hr/interruption respectively

*(Source: Comprehensive Review Based on the Impact of Integrating Electric Vehicle and Renewable Energy Sources to the Grid by Pampa Sinha, Kaushik Paul, Sanchari Deb, and Sulabh Sachan)*

The effect of electric vehicle chargers on the voltage distribution network in a home was investigated in the paper reviewed. Evidence from public chargers in the Netherlands was used to model the charging process. The analysis of the consequences was done in three different cases. Uncontrolled charging was studied first, followed by smart charging, and finally bidirectional V2G. The simulations showed that the network performance metrics were suitable for a high density of EVs per charger. Nevertheless, an increase in the number of electric vehicles using a single charger will cause long wait times and irritate EV owners.

In addition, it was discovered that clever charging procedures will raise the transformers' maximum loading. The authors of reviewed paper looked at the environmental effects of home EV charging in Arizona, USA. In this study, we looked at information from the smart meters of around 1600 residences that have electric vehicles. The demand for residential load was shown to rise by 7–14% if EV charging occurred during summer peak hours (6 PM to 8 PM).. The authors of referred paper suggested a novel methodology to construct the profiles of EV charging demand that takes into account the driving patterns of EVs, energy consumption, and charging schedules.

To test how charging electric vehicles would affect the electricity grid, a simulation was run using the suggested EV demand model. Saudi Arabia's distribution system was used to verify the model. The authors of referred paper offer a bottleneck model to examine the effects of the bidirectional discharging by V2G method on waiting times and traffic congestion. The model also took into account the potential loss owing to waiting time versus the potential gain due to discharge. The influence of smart charging on tariffs, peak load reduction, and carbon footprint reduction is investigated. They concluded that 30% to 50% of the nighttime peak load for EVs might be avoided if more people used smart charging at home. Furthermore, through valley-filling with work charging, a 10% reduction in carbon footprint can be accomplished.

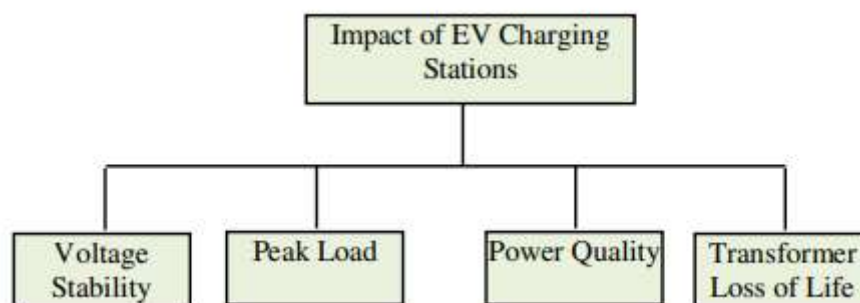
The effects of EV charging loads on power grid parameters such as voltage profile, stability, power quality, and harmonics were investigated by the authors. Opportunities for EVs to be used as a flexible resource were also explored, and EV loads were modeled as mobile loads.

The authors looked into the viability of the current system for accommodating EVs. Grid factors such as transformer loading, power factor, voltage profile, and phase imbalance were examined to see how they might be impacted by the increased loading caused by EV charging. The authors have simulated how EV chargers will affect the LV home network.

They came to the conclusion that uncoordinated charging and concentrating the EV load on power distribution network weak spots could be harmful to grid stability. Several charging scenarios, including “dumb” charging, “coordinated” charging without network constraints, and “coordinated” charging with network limitations, were examined for their effects on the Norwegian grid by the authors. It was determined that if the percentage of EVs on the road increased above 20%, there would be over-loading of wires and transformers. Guwahati, a city in northeastern India, was used to verify the model’s accuracy for its distribution network.

### **B. Study conducted by Deb, Kalita, & Mahanta, 2017, Impact of EV Charging Station on Power Grid, the parameters discussed are:**

However, the favorable impacts of chargers on the power distribution network can also be achieved by implementing the V2G concept. The operating parameters affected by placement of charging station are illustrated in Figure below



**Figure 5: Impact of EV charging station on power grid**

#### **Voltage Stability**

The threat to voltage stability is one of the most crucial adverse impacts of EV charging station. Theoretically, voltage stability is defined as the capability of power system to sustain steady voltages at all the buses after withdrawal of disturbances. Sudden increase in load is one of the key factors responsible for voltage instability. Due to charging of EVs there is sudden increase in load which results in voltage instability. In the reviewed paper, it is presented a simulation model of EV penetration in the power system distribution network of Otto-von-Guericke University Magdeburg. The different scenarios of EV penetration were generated based on real time data of arrival and departure of the vehicles. They investigated the voltage stability at each and every node of the distribution network and concluded that the generated scenarios do not cause voltage instability. In the paper, it is identified the weakest bus in the 13 bus network in presence of plugged in hybrid vehicle (PHEV) charging station based on a positive sequence voltage ranking index.

It is proposed a novel methodology for dynamic stability analysis of power system network in presence of EV charging loads.

### **Peak load Demand**

The increased load demand for EV charging results in rise in the peak load demand of the grid which is accompanied by decrease in reserve margin. In paper, it is analyzed the effect of uncontrolled EV charging on daily load profile. They also showed the improvement in load profile by incorporating coordinated charging. In paper, it is concluded that disorderly charging will increase the peak load demand and recommended tariff-based charging. In the reviewed paper, it is analyzed the variation in peak load demand of the network due to presence of EV fast charging stations in the highways.

### **Power Quality**

Theoretically, power quality is the capability of power distribution network to supply a stable and disturbance free output which is within voltage and frequency tolerances. The non linear characteristic of the EV charging load is a threat to power quality. Harmonics, Voltage sag are some of the common power quality problems.

Harmonics are sub-components of current or voltage waveforms whose frequency is integral multiple of the reference frequency. Harmonic is measured by total harmonic distortion (THD) which is the level of difference between actual obtained and reference frequency. In the paper, it is analyzed the effect of EV charger load on harmonic voltages of distribution system based on some statistical analysis. They classified the chargers based on THD produced. They also concluded that even with 45% of EV penetration there is negligible voltage distortion during

### **Transformer Performance**

Large scale deployment of EVs produces additional stress on the distribution transformers which plays a prominent role in decreasing the life cycle of the transformer. Increase in load causes increase in hot spot temperature of the transformer. The charging of EVs cause increase in load which in turn causes increase in hot spot temperature. The authors analyzed the impact of coordinated charging; tariff based charging and uncoordinated charging on transformer loss of life and concluded that uncoordinated charging is detrimental to the performance of transformer. The researchers did similar type of analysis and concluded that uncoordinated charging accelerates the ageing of transformers.

### **2.6.2 Challenges/mitigation of EV Integration to Grid, Power Issues, Energy Issues as per Use Case & Location of Charging Station**

The safe operation of the power network may be compromised with the increasing EV numbers. EVs have the capacity to serve as additional load as well as distributed flexible load. The challenges imposed by the grid integration of EVs can be divided into power issues, energy issues, and grid reinforcement. A summary of these challenges is presented in Table below.

**Table 9: Challenges of EV Integration to Grid**

<b>Use Case</b>	<b>Locations</b>	<b>Power Issues</b>	<b>Energy Issues</b>	<b>Grid Reinforcement</b>
Public slow charging	Street parking, Social/recreational areas, Park & Ride	For multiple installations, significant impacts can be expected in Secondary Substations (MV/LV transformers)	No significant issue	It could be necessary to replace MV/LV transformers and/or MV and LV feeders
Home private charging	Single houses, apartments, hotels, offices	Voltage issues can be expected in rural areas	No significant issue	It could be necessary to replace MV/LV transformers and/or MV and LV feeders
High Power Chargers “Fuel Station” Model	Fast chargers (50–150 kW) in existing fuel stations	Single installations may require a significant increase of power absorption	Energy withdrawal from the network could be significant	It could be necessary to install a dedicated MV substation with additional cost and time. MV lines (and in some cases, MV/LV transformers) could need to be replaced
Urban hyper hubs	Hyper fast chargers (150–350 kW) in new dedicated areas designed for cars in urban areas	Loads generated by EV charging add up to other LV and MV loads. The impacts could be significant, also on MV lines	No significant issue	MV lines (and in some cases, MV/LV transformers) could need to be replaced

<b>Use Case</b>	<b>Locations</b>	<b>Power Issues</b>	<b>Energy Issues</b>	<b>Grid Reinforcement</b>
Bus depots	High number (tens/hundreds) of buses performing night charging	A single deposit could require 5–10 MW, often in urban areas. There is a strong need for coordination between grid operators and local public transport operators	Moderate additional energy demand	In the event of the high number of buses, new primary substations could be required
Highway hyper hubs	Hyper fast chargers (150–350 kW) in new dedicated areas on highways both for cars and for heavy duty vehicles	A single hub could require more than 10 MW, often in rural areas. There is a strong need for coordination with grid operators in order to locate hubs close to existing HV lines	Energy withdrawal from the network could be significant but no issues are expected	A new Primary Substation would be required. A well-planned location would minimize the need for new HV lines
Company fleets	Pool vehicles (utilities, public services, private companies)	For multiple installations, significant impacts can be expected in Secondary Substations (MV/LV transformers)	No significant issue	It could be necessary to replace MV/LV transformers and/or MV and LV feeders

(Source: *Comprehensive Review Based on the Impact of Integrating Electric Vehicle and Renewable Energy Sources to the Grid* by Pampa Sinha, Kaushik Paul, Sanchari Deb, and Sulabh Sachan)

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### **2.6.3 Mitigation of Grid Impact Study as Power Factor, Load Factor, Harmonics, Voltage Deviations Integration EV Charging Station to Grid**

As per the national and international reviews, regulations were developed, and the following mitigation measures were implemented.

#### **2.6.3.1 Mitigating Equipments:**

1. Dedicated Circuits
2. Surge Protective Devices (SPDs; also known as Transient Voltage Surge Suppressors, TVSS)
3. Lightning Arresters
4. End-User SPDs
5. Power Line Filter
6. Isolation Transformers
7. Line Voltage Regulators
8. Ferroresonant Transformers
9. Tap Switching Transformers
10. Power Conditioners
11. UPS Systems
12. Isolated Grounding Outlets

*Source: Power Quality Energy Efficiency Guide*

#### **2.6.3.2 Mitigation strategies to mitigate/resolve the impacts to the grid brought by the heavy-duty EV charging stations**

- a) **PV-ES-CHARGER SOLUTION:** The reactive power support is assumed as a function of the charger to effectively boost the voltage when the charging load is lowering the system voltage. However, when the charging load is significantly high, reactive power can no longer effectively raise the voltage, and some on-site real power generation is needed to offset part of the charging load. Therefore, an on-site PV system plus energy storage become a promising option (Zhu, Mishra, Mather, Zhang, & Meintz, 2023).

**PV-ES-CHARGER SIZING STRATEGY:** To balance the sizes of each part of the PV-ES-charger on-site solution, we propose a methodology to achieve the optimal size combinations of the PV, ES, and smart charger, with the objectives of maintaining the system voltage within limits and minimizing the total capital cost of the on-site PV-ES-charger solution (Zhu, Mishra, Mather, Zhang, & Meintz, 2023)

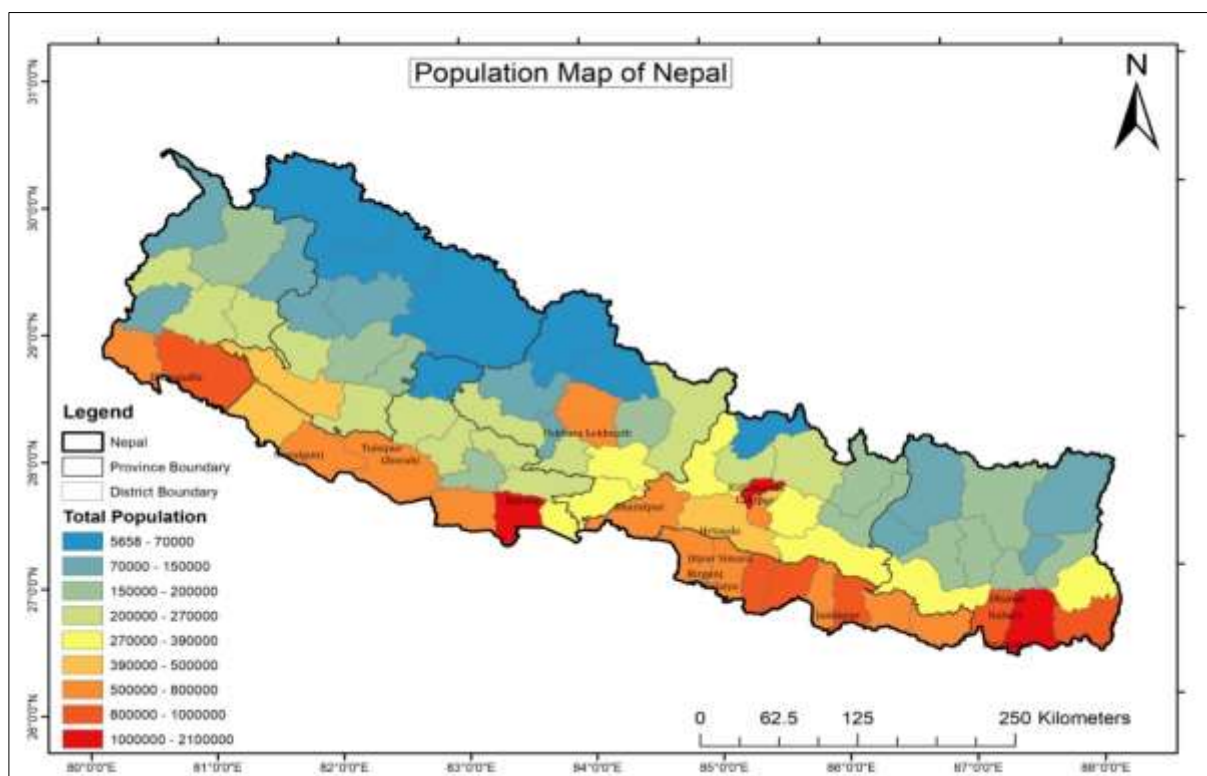
## 2.7 SELECTION OF NATIONAL HIGHWAY AND OPTIMAL LOCATION SELECTION FOR EVPCI

### 2.7.1 Selection of National Highway for EVPCI

#### 2.7.1A. Major Cities and their Population

The total population of Nepal, as of the census day (25 November 2021) is 29,164,578. Nepal has a predominantly rural population. However, urban areas have been growing due to migration and economic opportunities. Kathmandu, the capital city, is the most densely populated area. The mountainous and hilly regions in the northern part of Nepal, including the Himalayas, have lower population densities due to rugged terrain and harsh living conditions. However, some valleys and towns have significant populations. The southern Terai plains have a higher population density compared to the mountainous regions. Cities like Biratnagar, Butwal, Janakpur, and Nepalgunj in the Terai have substantial populations. The mid-hill regions have varying population densities. Some areas are densely populated while others are more sparsely populated.

Below we have shown the population distribution data throughout the country using GIS map.



Source: Created in ArcGIS from CBS 2021

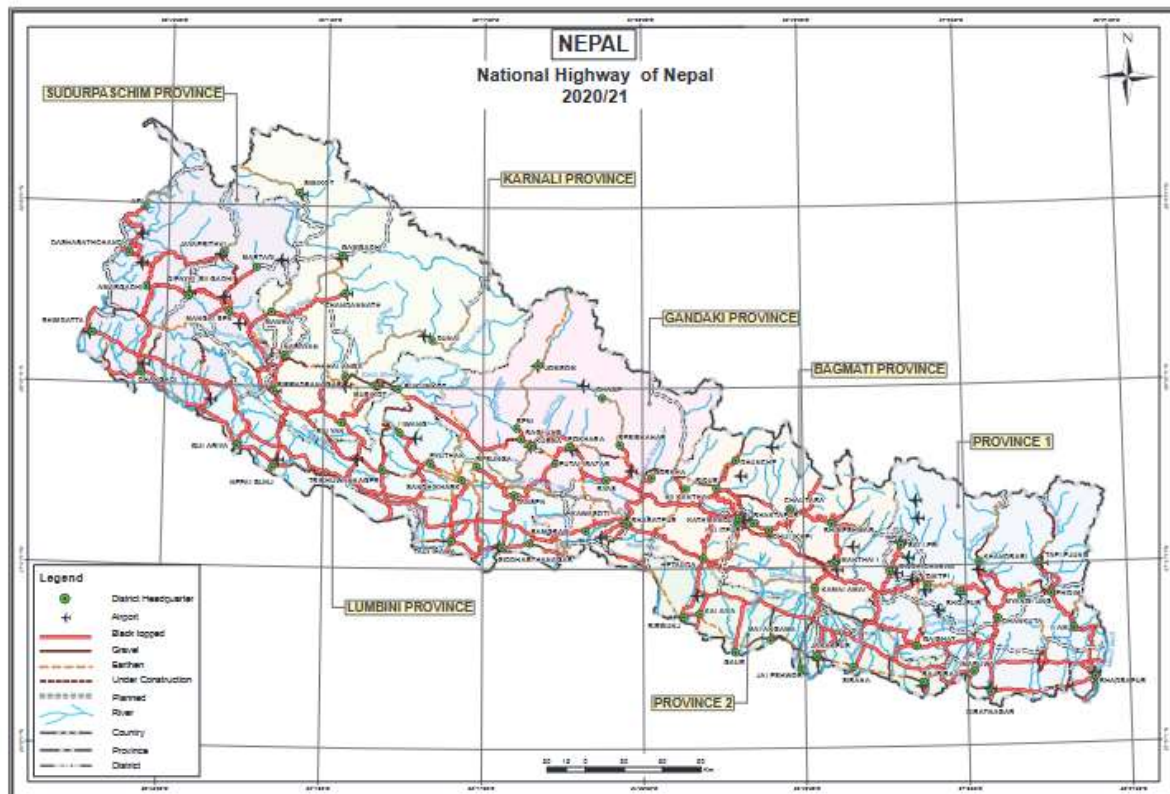
**Figure 6: Population map of Nepal**

#### 2.7.1B. Statistics of National Highway, SNH-2020/21

National Highways are administered by Department of Roads under Ministry of Physical Infrastructure and Transport (Nepal). According to the Statistics of National Highway SNH-2020/21, there are 80 National Highways in Nepal which sums to 14,913 km long in total

distance. Name of these highways with their length are shown in Annex I. Among them, many are in stages of planning and development.

### 2.7.1D. Traffic volume



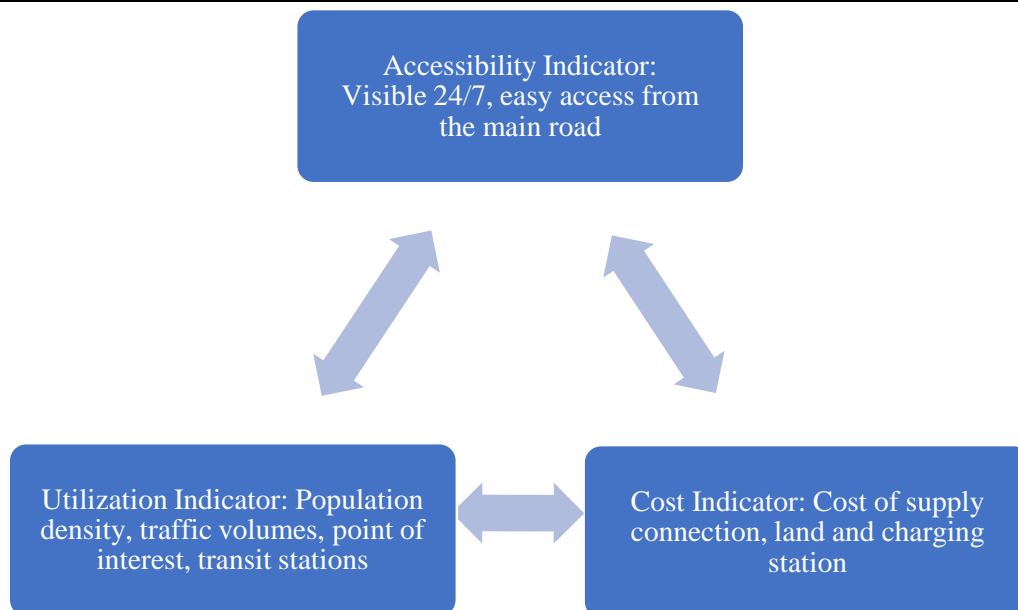
Source: [SNH-2020/2021](#)

**Figure 7: National Highways of Nepal**

The road link, its location and the respective AADT in PCUs of the major locations at National Highways are recorded and managed by Highway Management Information System (HMIS) UNIT, Department of Roads. The volume of penetration rate of vehicles can be determined and identified for the traffic count data. Higher the AADT value for the specific reach signifies the greater importance for the major National Highway selection. Placing charging stations in locations with high traffic volume helps promote electric vehicle adoption by providing convenient charging options for a broad audience. East-West Highway, Kathmandu Ring Road, Prithvi Highway, Araniko Highway, BPK National Highway are some of the major National Highways with significant traffic volume. Traffic Count in PCU of 160 road links of the nation has been attached in Annex II.

### 2.7.2 Selection of Location for Public Charging Infrastructure

Planning the location of public charging infrastructure enables the selection of the best sites for their installation.



Source: Handbook of Electric Vehicle Charging Infrastructure Implementation, Niti Ayog, India

### Figure 8: Principle of selection of location for public EV charging station

#### 2.7.2A. Maximize Accessibility

Accessibility refers to the ease of finding and reaching public charging stations from any given place. This includes areas where the demand for charging might be low but where some fundamental infrastructure is still necessary. Strategic network planning and selecting optimal locations play a crucial role in improving the accessibility of EV charging station. As the quantity of charging stations increase across a specific area, the typical distance EV users need to cover to access public charging stations diminishes.

The availability of 11kV/33kV distribution line and telecommunication system (3G/4G/5G/CAN/PLC) for power supply and communication makes the EV ecosystem more reliable and accessible.

Existing petrol stations are potential locations for electric vehicle charging stations. The existing petrol stations can be considered as suitable locations for electric vehicle charging stations because these areas are located according to the current traffic network. If the location is close to petrol stations, it will be more suitable. Also, the existing charging stations are also considered while selecting the location for proposed charging stations.

#### 2.7.2B. Maximizing Utilization

To achieve high use, public charging infrastructure should be placed where there is a need for charging. The demand for public charging at a particular location will depend on several factors, such as the population and employment densities, parking accessibility, traffic volumes, and the presence of tourist attractions, transit stations, and other commercial establishments and other points of interest.

Public charging stations for electric vehicles (EVs) are also strategically located to serve various industries, amenities, cultural and historical sites, religious centers, and tourism destinations. Placing charging stations in these locations ensures that electric vehicle users have convenient access to charging infrastructure.

### **2.7.2C. Minimize Cost**

The price of electric vehicle charging equipment, the price of the land, and the price of the power supply are the three main determinants of the cost of public charging infrastructure. By using a dispersed charging network of standard power charging points instead, which are less expensive, take up less area, and use less electricity overall, all three can be greatly decreased.

### **2.7.2D. GDP**

A map layer based on GDP rate of Municipality/ District/ Province will be created to consider economic factors. The areas featuring a high-GDP rate are considered more suitable for charging stations.

### **2.7.2E. Space Requirement for Charging Facilities**

Adequate space allocation at any electric vehicle (EV) charging facility involves accommodating vehicle parking, movement areas, charge point installations, necessary signage, barriers, and any electrical infrastructure needed. Typically, the space requirement for a car parking bay is about 5 x 2.5 meters. When considering the circulation space for vehicles, the Equivalent Car Space (ECS) needed for car parking ranges from 23 to 32 square meters, depending on whether it's an open parking area or situated in a basement. This ECS measurement serves as a guideline to estimate the number of chargers needed for the facility.

The number of chargers to be provided is determined by considering the parking location and charger specifications. For instance, depending on these factors, wall-mounted or pedestal-mounted chargers might be deployed, which would increase the required space within the parking area. Thus, a thorough assessment of the space and the specific charger types chosen will be instrumental in finalizing the number and placement of charging points.

Minimum infrastructure for Public Charging Station as per MBBL-2016 for Electric Vehicle Charging Infrastructure, India:

- i. An exclusive transformer with all related substation equipment including safety appliances
- ii. 33/11 KV line/cables with associated equipment including as needed for line termination/ metering etc.
- iii. Appropriate civil works.
- iv. Adequate space for Charging and entry/exit of vehicles
- v. Current international standards that are prevalent and used by most vehicle manufacturers internationally are CCS and CHadEMO. Hence. Public Charging Stations shall have, one or more electric kiosk/boards with installation of all the charger models:
- vi. The kiosk/board may have options for installation of additional chargers if required.

- vii. The Public Charging Station Providers are free to create Charging Hubs and to install additional number of Kiosk/Chargers in addition to the minimum number of chargers prescribed above.
- viii. Tie up with at least one online Network Service Providers (NSPs) to enable advance remote/ online booking of charging slots by EV owners. Such online information to EV owners should also include information regarding location, types and numbers of chargers installed/available, etc.
- ix. Appropriate public amenities.
- x. Where, in addition to the above, fast charging facility is also planned to be provided at the PCS by the PCI provider, the following additional infrastructure must be provided:
  - a. Appropriate Liquid Cooled cables if High Speed Charging Facility for onboard charging of Fluid Cooled Batteries (FCBs) is also planned.
  - b. Appropriate Climate Control Equipment for Fast Charging of Batteries to be used for swapping (i.e. not onboard)

#### **2.7.2.F. GIS and MCDM method**

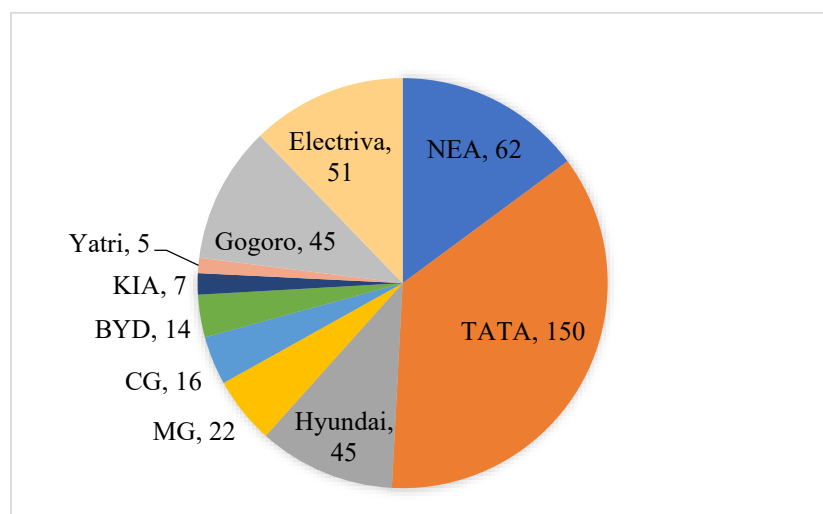
It has been observed that one of the main issues facing the transportation industry as a result of ICEs is carbon dioxide (CO<sub>2</sub>) emissions, which also contribute to global warming. EVs can assist with a few environmental issues to lower carbon emissions in cities. Electric vehicles are among the most promising forms of alternative transportation. When compared to conventional automobiles, the economic and environmental benefits of EVs have increased (Faria, Moura, Delgado, & de Almeida, 2012). The widespread adoption of electric cars is still hampered by a number of issues, despite their advantages. Currently, EVs make up a very small portion of the market (Egbue & Long, 2012). EVs' limited range, lack of charging facilities, and expensive initial prices are their main disadvantages (Aruldoss, Lakshmi, & Venkatesan, 2013). Range anxiety among first-time buyers is exacerbated by short driving distances and a dearth of charging stations, which lessens the financial advantages of EVs and delays their adoption in the automotive sector. Since EV charging station (EVCS) placement might have a detrimental impact on public adoption of EVs, effective planning and allocation are necessary (Ahn, Jun, & Yeo, 2016). This calls for the ongoing development of their charging infrastructure, especially with regard to choosing the best location for the installation of charging infrastructures, which function similarly to petrol stations and are meant for usage in public and commercial applications (Yong, Ramachandaramurthy, Tan, & Mithulananthan, 2015). The distribution and location of charging stations is crucial for widespread adoption of electric vehicles. Strategic placement can reduce the number of people buying new electric vehicles and address concerns about driving range. The effects of location on charging station placement are essential. If there are enough stations and they are positioned appropriately, EV drivers won't worry about running out of battery charge. However, limited availability can cause concern during commutes. Insufficient or improper charging station placement can affect EV driving patterns, affecting movement.

## Site selection strategies for EVCS

The goal of the charging station and placement challenge is to locate the charging stations in the transportation network in the best possible location with the least possible influence on the operational characteristics of the distribution network. Since EVs are growing in popularity and the transportation sector is electrifying, scientists and researchers are examining charging stations. As previously said, the inadequate charging infrastructure, appropriate station placement, and charge scheduling in the stations are the primary obstacles to the widespread adoption of EVs. A well-established charging infrastructure can help address some of the problems associated with EVs, such as their cost and range. Since EVs were not yet a reality when the road and grid infrastructure was constructed, picking the best site for charging stations may be difficult. Researchers have been examining data over the last few years and have determined what they consider to be the generally optimal spots for EV charging stations. (Deb, Tammi, Kalita, & Mahanta, 2018).

## 2.8 EXISTING PUBLIC CHARGING STATIONS IN NEPAL

NEA has installed fifty-two fast charging stations all over the country and other EV suppliers are installing their own charging stations to attract the consumers and to support the growth of EV across the country.



**Figure 9: Number of charging stations in Nepal**

Source: <https://ChargingstationNepal.com/charge-points>

TATA Motors has set up more than 150 fast and slow charging stations in Nepal. The company has been actively increasing the number of charging points with 26 DC fast charging places and over 130 AC charging stations. Hyundai has set up 43 charging stations in Nepal, MG has 17 charging stations, CG's Neta has 16 charging stations, and BYD has installed 14 charging stations, KIA has 7 charging stations in Nepal.

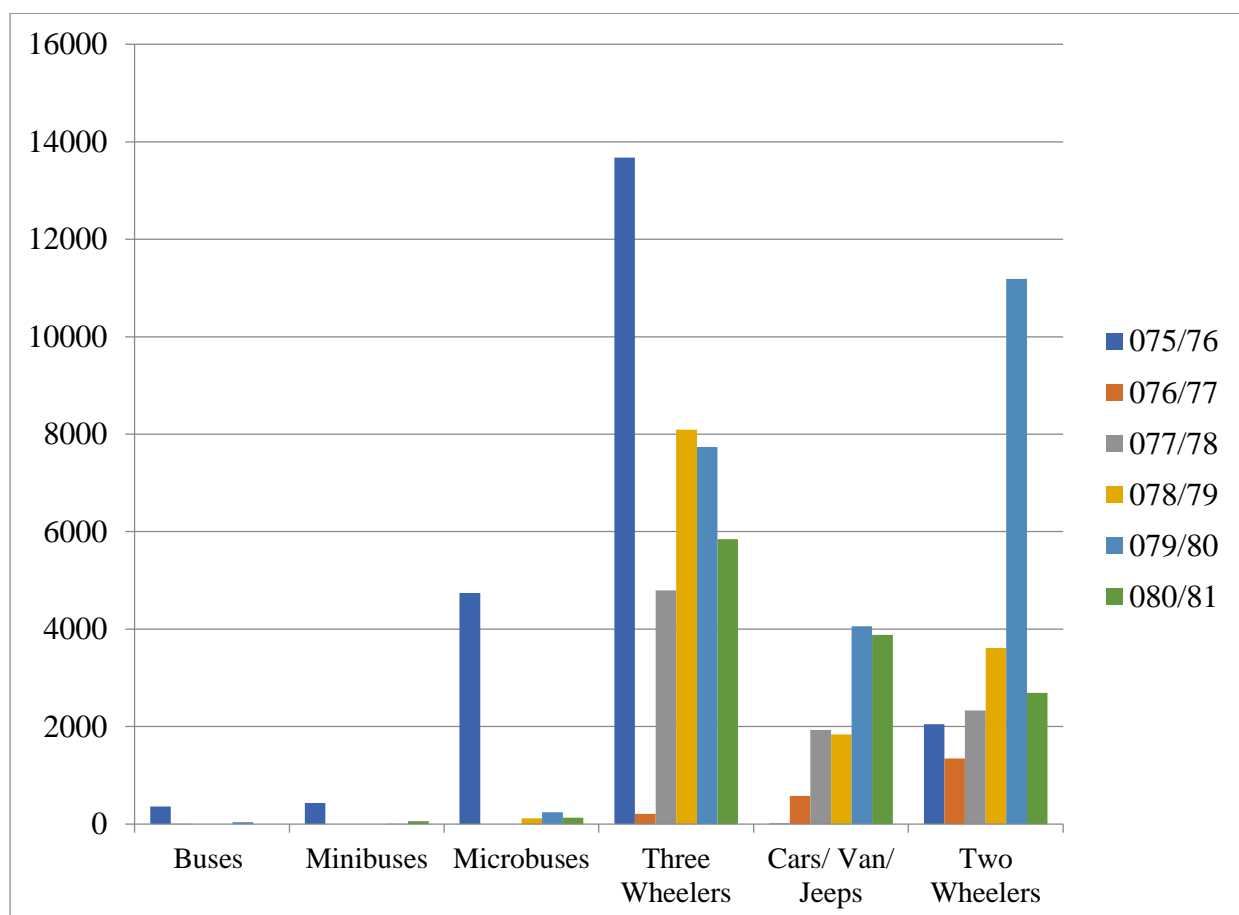
**Table 10: Number of Charging Stations in Nepal**

Organization/Companies	Charging Station
NEA	62
TATA	150
Hyundai	45
MG	22
CG	16
BYD	14
KIA	7
YATRI	5
GOGORO	45
ELECTRIVA	51
<b>Total</b>	<b>417</b>

Source: <https://ChargingstationNepal.com/charge-points>

### 2.8.1 Electric Vehicles (EV) Penetration and Market Trend in Nepal

Use of electric vehicles has been gradually growing, although it is still in the early stages of development compared to some other countries. Currently the electric vehicles in Nepal are limited to passenger vehicle.



Source: Department of Customs

**Figure 10: Imported Electric Vehicles in Nepal**

**Table 11: No. of Imported Electric Vehicles in Nepal in different F/Y**

Vehicle Types	075/76	076/77	077/78	078/79	079/80	080/81	Total
Buses	358	5			37		<b>400</b>
Minibuses	436				3	56	<b>495</b>
Microbuses	4,745			119	241	134	<b>5,239</b>
Three Wheelers	13,674	208	4,797	8,091	7,740	5,846	<b>40,356</b>
Cars/ Van/ Jeeps	14	575	1,931	1,838	4,062	3,880	<b>12,300</b>
Two Wheelers	2,047	1,349	2,333	3,610	11,184	2,690	<b>23,213</b>

Source: Department of Customs

## 2.8.2 Projection of EV penetration of EV

Based on the projections of EV penetration within different vehicle segments, the charging demand, and the share of charging to be fulfilled by public charging stations, the number and type of public chargers required in Bengaluru for the horizon years 2025 and 2030 calculated in this handbook are referred in the following tables for the steps 1-7 of above which will be referred for upcoming phases.

STEP 1: EV Projections for Horizon Years, by Segment.

Vehicle Segments	Annual growth rate	EV penetration rate - 2025	Total number of EVs - 2025	EV penetration rate - 2030	Total number of EVs - 2030
E-2W	5.88%	10%	1,00,477	30%	6,12,353
E-3W (passenger/cargo)	5.57%	40%	30,376	70%	1,15,804
E-car (personal)	3%	3%	4,519	15%	4,2561
E-car (commercial)	15.80%	10%	4,775	30%	41,992

STEP 2-3: Charging Demand by Vehicle Segment

Vehicle Segments	Daily kms driven	Battery capacity in kWh	Driving range in km/full charge	Daily charging demand in kWh	Total daily charging demand in kWh - 2025	Total daily charging demand in kWh - 2030
E-2W	40	2.5	80	1.25	1,25,596	7,65,442
E-3W (passenger/cargo)	120	7	100	8.4	2,55,162	9,72,757
E-car (personal)	40	30.2	312	4	17,498	1,64,786
E-car (commercial)	100	21.2	181	12	55,931	4,91,838

## STEP 4-7: Type and Number of Public Chargers (25% Utilization)

Vehicle Segments	Share of public charging	Charger Types	Number of chargers - 2025	Number of chargers – 2030
E-2W	10%	Single phase 15A charger	634	3866
E-3W (passenger/cargo)	20%	Single phase 15A charger	2,557	9826
E-car (personal)	10%	Type-2 AC (70%) 50kW DC charger (30%)	32	306
E-car (commercial)	25%	Type-2 AC (60%) 50kW DC charger (40%)	262	2303

Source: (NITI Aayog, Ministry of Power (MoP), Department of Science and Technology (DST), Bureau of Energy Efficiency (BEE), WRI India, 2021)

## 2.9 SITE PLANNING

It is crucial to keep the amount of space needed for charging stations as low as possible. Therefore, site planning is crucial for integrating EV charging infrastructure. Planning the site will be done so that the least amount of area possible is used while still providing all facilities. Additionally, it depends on the location of the charger and how many and what kind of EV charge stations must be provided there.

There are two primary installation choices for EV charging equipment: pedestal-mounted and wall-mounted solutions. Equipment for wall-mounted charging is mounted to a wall or other vertical surface. Compared to pedestal-mounted charging equipment, it is often less expensive and takes up less space. Similar to freestanding charging stations, pedestal-mounted equipment is mounted on a post or pole. It costs more and takes up more room than wall-mounted charging equipment.

Load	Recommended Distributed transformer installation	Minimum area requirement
100 KW to 300 KW	Installation of one 11 kV pole or plinth mounted DT	4 m x 4 m (pole) 8 m x 5 m (plinth)
300 KW to 700 KW	Installation of one 11 kV plinth mounted DT	9 m x 5 m
700 KW to 1,500 KW	Installation of two 11 kV plinth mounted DTs	10 m x 8 m

(NITI Aayog, 2021)

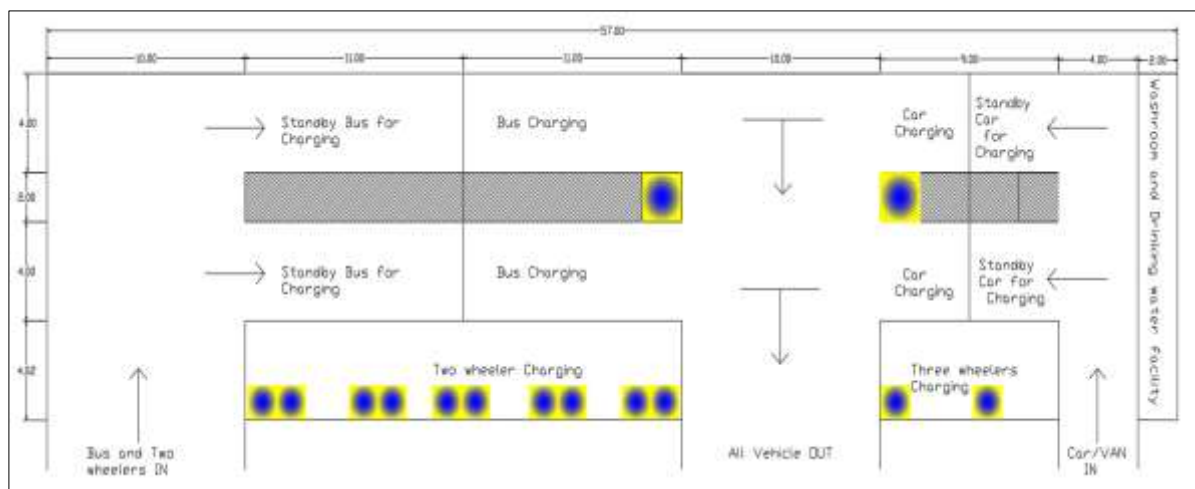


Figure 11 : Sample of Layout for Charging Staiton

**Approximate Coverage Area Calculation for charging station**

SN	Type of EV	No of EV	Size(m)	Area(sqm)
1	Bus/Truck	5	10x3.5	175
2	Car/Jeep/Other 4W	10	4x2.5	100
3	Tempo	5	3x2	30
4	Motorcycle and Scooter	10	2x1.5	30
5	Charging stand Area	4+4+4	5x5	300
<b>TOTAL (1+2+3+4+5) =</b>				<b>635</b>
6	Standby space for same number of EV at same time	16		635
7	Toilet	10	2x2	40
8	Canteen and Others	1	15x20	300
<b>TOTAL (1+2+3+4+5+6+7+8) =</b>				<b>1610</b>

Ropani-Anna-Paisa-Dam= 3-2-2-2 (Approx. 3 Ropani)

Bigha-Katha-Dam= Approx 5 kattha

**2.10 ROAD GRADIENT EFFECTS ON EV ENERGY CONSUMPTION**

**1. Physics-Based Approaches**

**Saldarini et al. (2022)** developed a force-balance model incorporating gravitational resistance ( $F_g = mg \sin \theta$ ), rolling resistance ( $F_r = C_r mg \cos \theta$ ), and aerodynamic drag ( $F_a = 0.5 C_d \rho A v^2$ ), validated across five EV models in Italy.

**Liu (2018)** quantified how gradients alter speed-acceleration distributions, showing **>5% slopes double energy demand** uphill and disrupt steady-state driving patterns.

**Li et al. (2017)** demonstrated that gradient inclusion improves energy estimation accuracy by **5–8%** through real-world GPS data analysis<sup>13</sup>.

## 2. Data-Driven Innovations

**Xiaowei et al. (2020)** proposed Generalized Energy-Consumption Rates (GECRs) using speed intensity, braking intensity, and slow-driving intensity to decouple driving behavior from inherent EV energy characteristics<sup>5</sup>.

**Huang et al. (2017)** optimized road grades numerically, achieving **31.7% energy savings** via sinusoidal slope designs<sup>3</sup>.

**Table 12: Road Gradient effect on Energy consumption**

Factor	Impact	Study
<b>Uphill gradients</b>	5–8% higher energy consumption per 5% slope increase	Li et al. (2017) <sup>1</sup> , Saldarini et al. (2022)
<b>Downhill recovery</b>	10–35% energy recuperation via regenerative braking	Sagaama et al. (2020), Liu (2018)
<b>Microgradients</b>	Low-speed ascents increase urban consumption by 0.22 kWh/km vs. 0.15 kWh/km on highways	IAET (2023), Xiaowei et al. (2020) <sup>5</sup>
<b>Testing accuracy</b>	Gradient-aware models reduce estimation errors to 3.84–7.12% in lab/real-world tests	Xiaowei et al. (2020)

### 2.11 REVIEW OF RELATED REGULATORY AND POLICY FRAMEWORKS

Government policies, incentives, regulations, and funding mechanisms aimed at supporting the development and deployment of public charging infrastructure were analyzed in further steps of the study. This included international comparisons of regulatory frameworks.

Some of the national policy and regulation that were referred throughout the project are:

- 16th Periodic Plan (2024/25–2028/29)
- Nationally Determined Contribution (NDC)
- National Transport Policy 2001
- National Environment Policy 2019
- Environment Protection Act 2019
- Ozone Depleting Substances Consumption (Control) rules (2001)
- Environment-friendly vehicle and transport policy 2014

- Statistics of Strategic Road Networks (SSRN)
- Statistics of National Highway SNH 2020/21
- National Road Standard 2070
- National Action Plan for Electric Mobility 2018
- Nepal Electricity Authority Act -2049
- NEA, Electricity Distribution Regulation- 2078
- NEA, Electricity Tarriffs Regulation -2078
- Land Acquisition Act 2019
- Motor Vehicle and Transport Management Act (MVTA) (1993)
- Motor Vehicle and Transportation Management (6th Amendment) Regulations 2073
- Motor Vehicle and Transportation Management Act 2049
- Motor Vehicle and Transport Management Rules (MVTMR) (1997)
- Emission Standard for In-Use Vehicles (1998)
- Unified Directive of Nepal Rastra Bank 2021

**Table 13: Review of Regulatory And Policy Frameworks**

S.N.	Policy/ Plan	Year	Target related to EVs
1	16th Periodic Plan	2024/25– 2028/29	Strategic plan prioritizing green growth, digital transformation, renewable energy expansion, and inclusive economic development aligned with national net-zero commitments.
2	National Transport Policy	2001	Sets vision for integrated, efficient, and safe transport system; encourages environmentally friendly practices.
3	National Environment Policy	2019	Promotes clean energy, sustainable mobility, and pollution control to meet national and global environmental targets.
4	Environment Protection Act	2019	Provide a legal mandate to reduce pollution through promotion of clean technologies like EVs; enable environmental screening for EV projects.
5	Ozone Depleting Substances Consumption (Control) Rules	2001	Promote EVs as a clean alternative to vehicles using ozone-depleting air conditioning or refrigerant systems.
6	Environment-Friendly Vehicle and Transport Policy	2014	Encourages electric and hybrid vehicles, tax incentives, and infrastructure development for green mobility.
7	Statistics of Strategic Road Networks (SSRN)	Various	Database providing length, type, and condition of Nepal’s major road networks vital for EVCS planning.
8	Statistics of National Highway (SNH)	2020/21	Annual statistical record on national highway conditions, routes, and usage patterns.

S.N.	Policy/ Plan	Year	Target related to EVs
9	National Road Standard	2070 (2013/14)	Sets technical standards for road width, safety features, and design crucial for EVCS site feasibility.
10	National Action Plan for Electric Mobility	2018	Establish a national roadmap for promoting electric mobility, including EV adoption targets, infrastructure planning, and incentives.
11	Nepal Electricity Authority Act	2049 (1992/93)	Governs NEA's operations in electricity generation, transmission, and distribution. Enables NEA to manage power supply and grid connectivity needed for EV charging stations.
12	NEA, Electricity Distribution Regulation	2078 (2021/22)	Regulates electricity service standards, grid connectivity, and distribution, relevant to EV charging.
13	NEA, Electricity Tariffs Regulation	2078 (2021/22)	Defines tariffs, including for EV charging categories; promotes rational pricing.
14	Land Acquisition Act	2019	Legal framework for acquiring land for public infrastructure, including EV charging stations.
15	Motor Vehicle and Transport Management Act (MVTA)	1993	Provides a foundational legal structure for vehicle registration and operation, but requires updates to fully integrate EVs.
16	Motor Vehicle & Transport Management (6th Amend.) Regulation	2073 (2016/17)	Includes provisions for EV registration, emission standards, and route permits.
17	Motor Vehicle & Transport Management Act	2049 (1992/93)	Core act governing vehicle registration, operation, licensing, and transport regulation in Nepal.
18	Motor Vehicle and Transport Management Rules (MVTMR)	1997	Operationalize EV-specific procedures such as registration, licensing, and inspection—currently outdated and under revision.
19	Emission Standard for In-Use Vehicles	1998	Indirectly supports EV transition by enforcing pollution control for internal combustion engine (ICE) vehicles.
20	Unified Directive of Nepal Rastra Bank	2021	<ul style="list-style-type: none"> <li>• Finance up to 80% for EVs while only 20% for ICEs</li> <li>• Tenure of auto loan for EVs up to 8 years whereas it is 5 years for ICEs</li> </ul>

Furthermore, as per **Second Nationally Determined Contribution (NDC)**, it includes policy targets in each section that are well aligned with Government of Nepal's 15<sup>th</sup> five-year plan, relevant sectoral policies and strategies, climate change policy, and other national documents. The specific targets related to the transportation sectors are:

- In 2025, sales of electric vehicles will be 25% of all private passenger vehicle sales, including two-wheelers and 20% of all four-wheeler public passenger vehicle sales (excluding e-rickshaws and electric tempos).
- By 2030, develop 200 km of electric rail network to support public commuting and mass transportation of goods.

Furthermore, as per Final **Third Nationally Determined Contribution (NDC-3.0)**, it includes policy targets in each section that are well aligned with Government of Nepal's 15<sup>th</sup> five-year plan, relevant sectoral policies and strategies, climate change policy, and other national documents. The specific targets related to the transportation sectors are shown in below table:

Table 14:NDC-3.0

Target Year	Target	Reference value (2025)	Costs (USD) and Conditionality
<i>(iii) Transport</i>			
2030, 2035	Increase sales of battery electric vehicles (BEVs) to 90% and 95% for all private passenger vehicles (including 2- wheelers), to 70% and 90% for all four-wheeler public passenger vehicles, and to 10% and 20% for all freight and waste collection vehicles by 2030 and 2035.	12.38% of private passenger vehicle sales were BEVs (46% of four-wheelers and 9.6% of two-wheelers). 29% of four-wheeler public passenger vehicle sales were BEVs (2023).	By 2035: 11.834 billion conditionals. Of this, by 2030: 5.701 billion conditional
2030, 2035	Build and operate at least 50 km by 2030 and 100 km by 2035 of integrated electric bus, trolley and light rail transit system in Kathmandu Valley.	0 km.	By 2035:17 billion conditional. Of this, by 2030: 2 billion conditional
2030, 2035	Build and operate 200 km by 2030 and 300 km by 2035 of the electric rail network to support public commuting and mass transportation of goods (freight).	0 km. Note: 112 km of railway trackbed laid of around 1000 km planned length. 52 km operational using diesel-electric multiple units.	By 2035: 6.7 billion conditional. Of this, by 2030: 4.47 billion conditional

Source: Nepal-NDC-3.0-Final Report

- Sufficient charging stations and infrastructure will be developed to meet the quantified BEV targets by 2030 and 2035. Electric vehicle standard, technical manpower, and dedicated service centers will be established by 2030 and government offices, education institutes and the health sector will prioritize the use of electric vehicles.
- Vehicle fitness test centers and a national research center for motor vehicles will be established by 2030, with infrastructure enhancement by 2035. Vehicle fitness standards and testing protocols will be implemented by 2035. Sustainable practices for battery recycling and skilled manpower will be developed including piloting by 2030.

- An effective public transport system in Kathmandu Valley and other metropolitan cities will be established by 2030 and in all other urban areas by 2035. Electric railways will be operated from Jaynagar- Janakpur- Bijalpura by 2030.
- By 2030, measures will be included in policies to offset the carbon footprint of emissions resulting from tourism transport.

Note: Nepal's NDC-3.0 sets specific sales targets for Battery Electric Vehicles (BEVs) by 2030 and 2035:

- Private passenger vehicles (2-wheelers + 4-wheelers):
  - 90% by 2030
  - 95% by 2035
- Public passenger vehicles (4-wheelers: minibuses, minibuses, buses):
  - 70% by 2030
  - 90% by 2035
- Freight & waste collection vehicles:
  - 10% by 2030
  - 20% by 2035

Successful implementations of public charging infrastructures in countries such as India, Bangladesh, European nations, and American nations were further studied to propose the standards, guidelines, assessment procedures, and most feasible planning and location of the charging stations around the country.

- Charging Infrastructure for Electric Vehicles – Guidelines and Standards, India
- Model building bye-laws (MBBL-2016) for electric vehicle charging infrastructure, India
- Handbook of electric vehicle charging infrastructure Implementation, Niti Ayog
- Electric vehicle charging infrastructure planning for integrated transportation and power distribution networks: A review, Tim Unterluggauer
- A combined Planning and Design Approach of a Public Charging Infrastructure for Electric Vehicles, Mario Porru
- European EV Charging Infrastructure Masterplan, 2022
- Design Guidelines and Standards of British Columbia Public Electric Vehicle Charging Stations, British Columbia, Canada, 2013
- Hillsborough TPO Electric Vehicle Infrastructure Plan, 2023

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## **2.12 PRIORITY FOR ROLLOUT OF EV PUBLIC CHARGING INFRASTRUCTURE OF SELECTED NATIONAL HIGHWAY FROM SNH 2020/2021:**

### **Phase I (1-3 Years):**

In MBBL-2016, India, for Electric Vehicle Charging Infrastructure, all Mega Cities with population of 4 million plus as per census 2011, all existing expressways connected to these Mega Cities & important Highways connected with each of these Mega Cities have been considered up for coverage in the first phase.

### **Phase II (3-5 Years):**

In MBBL-2016, India, for Electric Vehicle Charging Infrastructure, big cities like State Capitals, Urban headquarters shall be covered for distributed and demonstrative effect Further, important Highways connected with each of these Mega Cities have been considered up for coverage in the second phase.

### **Phase III (5-8 Years):**

In MBBL-2016, India, for Electric Vehicle Charging Infrastructure, other cities like remaining Ur headquarters shall be covered for distributed and demonstrative effect Further, important Highways connected with each of these Mega Cities have been considered up for coverage in this phase.

## **2.13 PPP MODEL FOR IMPLEMENTATION MODALITY**

Implementing public charging infrastructure for electric vehicles (EVs) through a Public-Private Partnership (PPP) model can be an effective way to leverage the strengths of both the public and private sectors.

### Proposed Financial Investment Modality for EV Public Charging Infrastructures

#### **1. Public Private Partnership share division**

Public: 51% share, Central/ Provincial/ Local governments

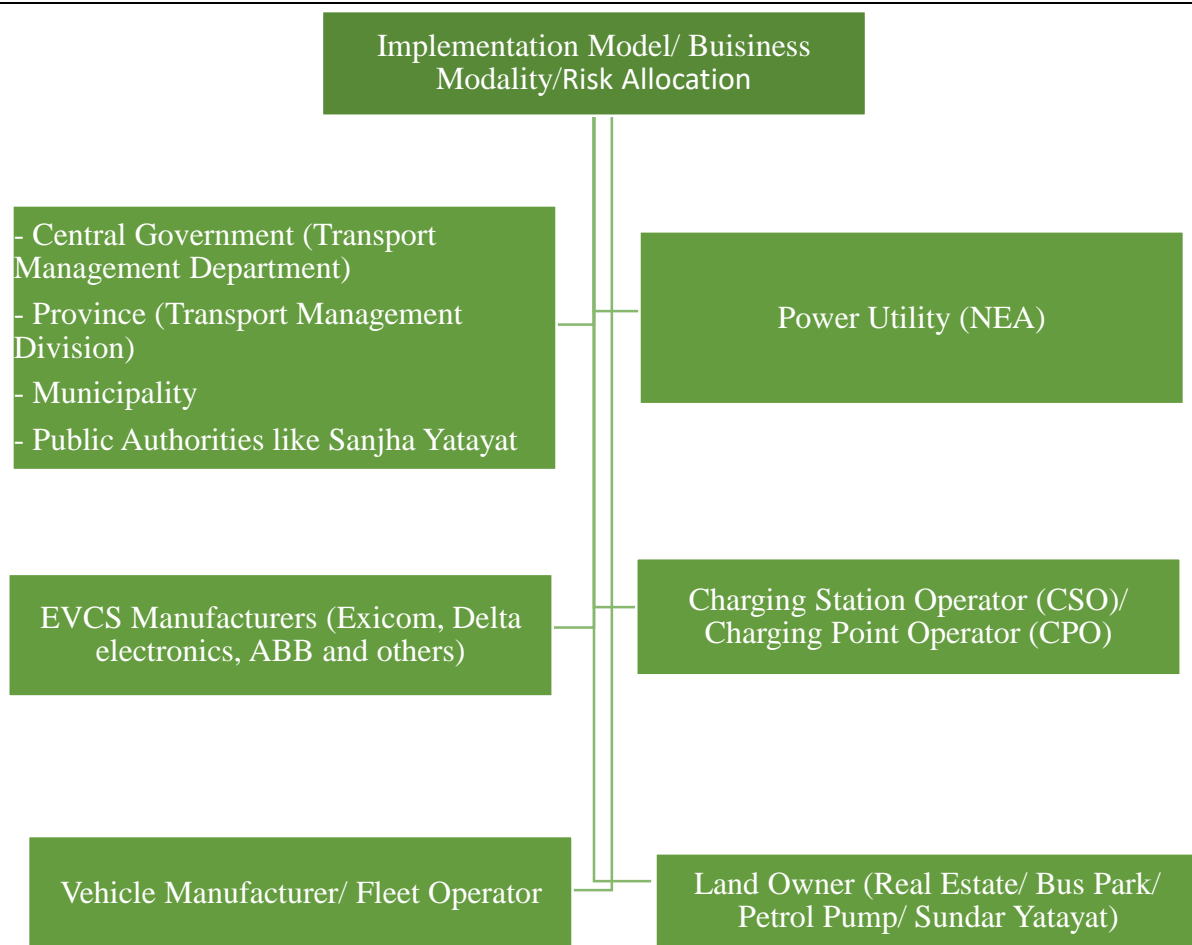
Private: 49% share, such as Manufacturer/ Supplier and Charging Point Operator (CPO)/ E-Mobility Service Provider (e-MSP)/ EV User, which can be by one or more than one private investors Private Public Partnership

#### **2. Private Public Partnership share division**

a.Private: 51% share, such as Manufacturer/ Supplier and Charging Point Operator (CPO)/ E-Mobility Service Provider (e-MSP)/ EV User, which can be by one or more than one private investors Private Public Partnership

Public: 49% share, Central/ Provincial/ Local governments

b.Private Investment: 100% Private share, such as Manufacturer/ Supplier and Charging Point Operator (CPO), which can be by one or more than one private investors



**Figure 12: Implementation Model/ Business Modality/ Risk Allocation**

#### Risk Allocation of Proposed Implementation Plan of PCI

The risks need to be identified and allocated/contributed appropriately between public and private sectors. International Practices on PPP model were studied. Major risks in the Anqing project (the largest charging infrastructure PPP project executed in China) are divided into seven categories: design/ construction, operation, financial, revenue, legal, government behavior, and others.

**Table 15: Risk Allocation of Implementation plan**

<b>Risk Category</b>	<b>Public</b>	<b>Private</b>
<b><i>Design/construction risk</i></b>		
Planning and site selection risk	√	
Land delivery and coordination risk	√	√
Design faults		√
Engineering technical faults		√

<b>Risk Category</b>	<b>Public</b>	<b>Private</b>
Labor and equipment acquisition		√
Expansion of power supply capacity		√
Construction preparation		√
General engineering variation		√
Cost overruns of construction and procurement		√
Completion risk		√
Site safety, environmental protection		√
<b><i>Operation risk</i></b>		
Facilities' technical defects		√
Commissioning test		√
Facilities and equipment failure		√
Cost overruns of operation and maintenance		√
Quality of service do not reach the standard		√
Grid load regulation		√
Operator default and early termination		√
Overhaul and asset replacement		√
Safety management in operation period		√
Environmental protection in operation period		√
<b><i>Financial risk</i></b>		
Financing failure		√
High financing costs		√
Interest rate change		√
Foreign exchange risk		√
Debt risk/liquidity risk		√
Bankruptcy	√	√
<b><i>Revenue risk</i></b>		
Change of electric car ownership/charging infrastructure utilization ratio	√	√
Government pricing changes, such as service fees	√	
Changes in other revenue		√
Inflation	√	√
<b><i>Legal risk</i></b>		
Contract document conflict	√	√

Risk Category	Public	Private
Third party default		√
<b>Government behavior risk</b>		
Government default and early termination	√	
Expropriation and nationalization	√	
Approval delay	√	
Special engineering variation	√	
Tax variation	√	√
Industry standard variation	√	√
Technology variation	√	√
<b>Other risk</b>		
Force majeure	√	√

Source: Kun Wang, Yongjian Ke, "Public-Private Partnerships in the Electric Vehicle Charging Infrastructure in China: An Illustrative Case Study", *Advances in Civil Engineering*, vol. 2018,

## 2.14 CHALLENGES AND FUTURE DIRECTIONS

Identification and discussion of challenges, barriers, and potential solutions in implementing a comprehensive public charging infrastructure network is essential. The change in trend in the future and technological advancement could impact EV charging station planning.

### Barriers against EV Use in Nepal

The adoption of Electric Vehicles (EVs) in Nepal faces various real and perceived barriers. These obstacles have been examined through an extensive literature review, encompassing an analysis of pertinent online content, previously published studies, and engagements with key stakeholders, including EV manufacturers, policymakers, technical experts, consumers, users, and relevant institutions.

Conducting a comprehensive literature survey, we searched keywords such as "electric vehicle," "barriers," "issues," "challenges," and "electric vehicle development in Nepal" on Google, Google Scholar, and Science Direct databases. The identified barriers underwent further refinement through consultations with experts and team leader. This methodical approach led to the categorization of barriers into five distinct categories: technical, policy, economic, infrastructure and social. The barriers and their respective classifications are presented in Table 16: Summary of barriers of EV adoption in Nepal

**Table 16: Summary of barriers of EV adoption in Nepal**

Categories of Barriers	Barriers
Technical Barriers	Limited range (one-time travel distance at full charge)
	Lack of evidence on reliability and performance
	Limited battery life

Categories of Barriers	Barriers
	Fewer EV models
Social Barriers	Lack of knowledge on EVs
	Lack of environmental awareness regarding EVs
	Consumers' limited understanding of the product quality of EVs
Economic Barriers	Higher purchase price
	Battery replacement cost
	Higher electricity price for charging
	Lack of credit access for EVs
Infrastructure Barriers	Lack of charging stations
	Lack of repair and maintenance workshops
	No domestic industry
Financing and investment Barriers	Limited investment in EV infrastructure due to perceived risks and uncertain returns
	Absence of government incentives for EV adoption at scale
	Absence of innovative financing mechanisms
Policy Barriers	Lack of long-term planning and goals on the government's part
	Absence of an annual tax exemption
	Absence of awareness raising about EVs

## 2.15 SUITABLE ROLLOUT IMPLEMENTATION PLAN FOR IDENTIFIED/SELECTED CHARGING INFRASTRUCTURE OF PHASE -1.

Following is the Proposed Suitable Implementation Plan:

Description of Works	1	2	3	4	5	6	7	8	9	10	11	12
Contract Agreement	■											
Work Team Mobilization	■											
Pre-construction survey		■										
Construction works			■	■	■	■	■	■	■	■	■	■
Preparation of as built drawings and SDS											■	■
Testing, Commissioning and Handover										■	■	■

*Note: The cost estimate, tendering process and their evaluation and award the tender will be covered for four to six months*

*Source: NEA Bidding Documents of EVCS*

CHAPTER 3: METHODOLOGY

3.1 MASTER PLAN FRAMEWORK

The detailed flowchart, shown in the chart, serves as a visual depiction of the comprehensive working schedule devised for the implementation of our master plan. It outlines the sequential tasks, phases, and their interdependencies to guide the project's timeline and facilitate effective management and execution for the “Preparation of Master Plan for Public Charging Infrastructure (PCI) on Major National Highways for Electric Vehicles (EV)”.

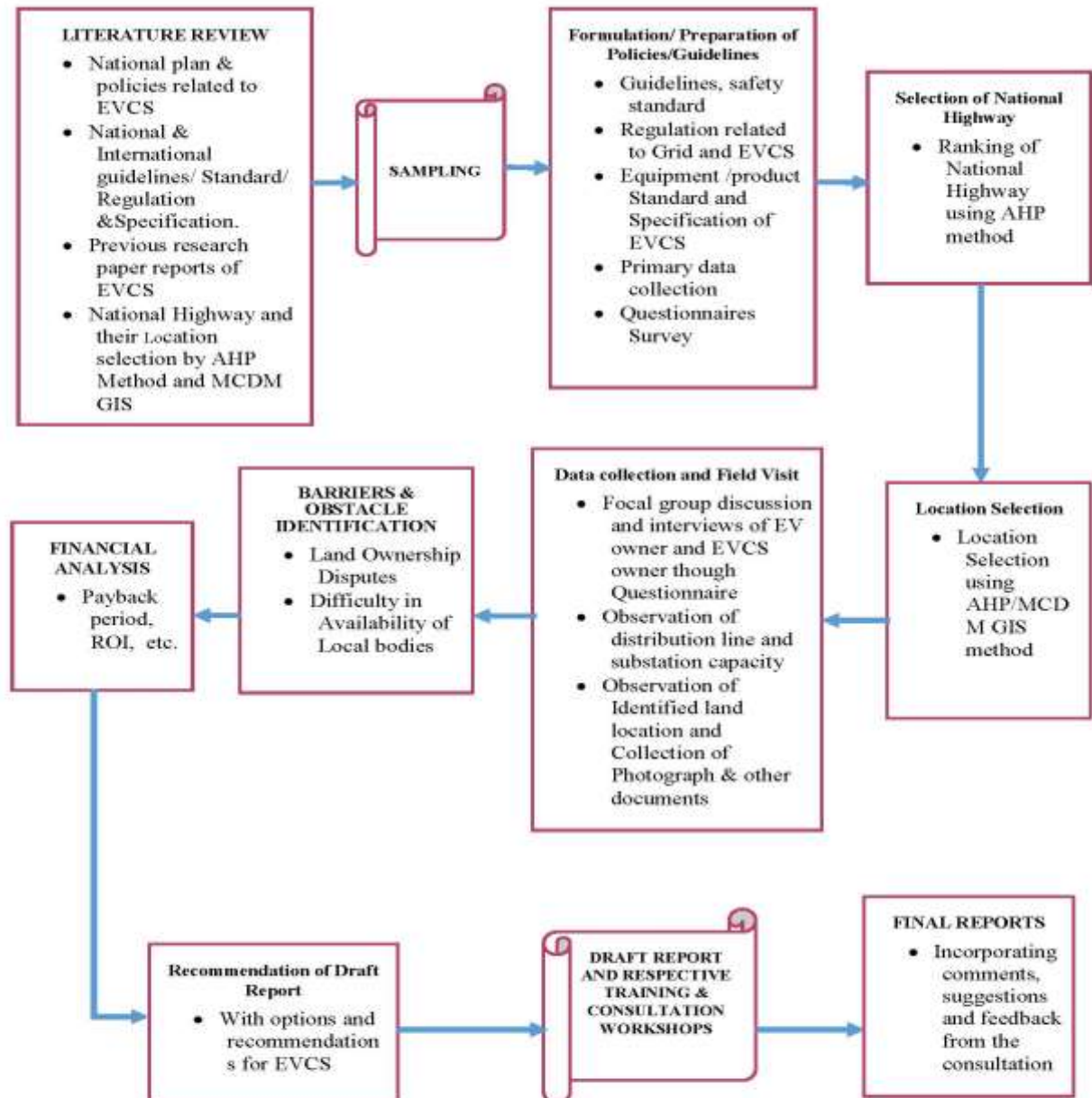


Figure 13: Methodological Flowchart

The systematic methodological flow diagram as shown in the figure was followed throughout the assignment to maintain high quality of work throughout the project. Various assessments were done in different stages of the work to ensure that the assignment is carried out systematically and is on time. Any obstacle during the assignment was handled by both formal and informal approach.

### **3.2 PREPARATION OF STANDARDS/ GUIDELINES FOR EVPCI**

The development of the new guidelines encompassed the following methodologies:

The development of the Master Plan for Electric Vehicle (EV) Power Charging Infrastructure (PCI) was executed through a comprehensive, multi-stage process involving the Water and Energy Commission Secretariat (WECS), a specialized consultant team, and key stakeholders such as the Nepal Electricity Authority (NEA) and other relevant agencies. The process commenced with detailed planning and scoping to define the objectives and framework for the guidelines and standards. This was followed by an extensive desk study and literature review, drawing on national and international references, including NEA Guidelines/Standards 2078 BS, the Ministry of Power (India) Guidelines, the 2022 Bangladesh EV Charging Guideline, and other pertinent documents. To supplement the desk research, structured questionnaires were developed for Focus Group Discussions (FGD) and Key Informant Interviews (KII), ensuring comprehensive stakeholder input. The findings from these activities were consolidated in an Interim Phase I Report, which was subsequently reviewed and refined through a stakeholder workshop. Feedback and suggestions from the workshop were systematically integrated into the draft, culminating in the preparation and submission of the Final Master Plan for EV PCI. This collaborative and iterative approach ensured that the final document is comprehensive, evidence-based, and aligned with both national priorities and international best practices.

### **3.3 PREPARATION OF SAFETY STANDARDS REQUIRED FOR THE GRID**

The methodology that has been adopted is as follows:

The development of the safety standards for Electric Vehicle (EV) Power Charging Infrastructure (PCI) was conducted through a structured and collaborative approach involving the consultant team and key stakeholders, including the Nepal Electricity Authority (NEA) and other relevant entities. The initial planning stage focused on scoping the topic, drafting, and formulating the safety standards framework for EV PCI. This was followed by a comprehensive development phase, which entailed an extensive desk study and literature review. The review examined existing systematic studies and assessed their adequacy with particular emphasis on safety aspects as outlined in the Nepal Electricity Authority's guidelines and bidding documents. Additionally, international benchmarks were considered, including the Electric Vehicle Charging Guideline 2022 from Bangladesh and other globally recognized safety standards for charging devices and stations. The findings and preliminary recommendations from these efforts were consolidated into an Interim Phase I Report, which was submitted by WECS in partnership with the consultant team and stakeholders. This report

laid the groundwork for subsequent refinement and validation of the safety standards to ensure alignment with both national regulatory requirements and international best practices.

### **3.4 PREPARATION OF REGULATIONS REGARDING POWER FACTOR, LOAD FACTOR, HARMONICS, VOLTAGE DEVIATIONS, ETC.**

The methodology that has been adopted is as follows:

The formulation of regulations for Electric Vehicle (EV) Power Charging Infrastructure (PCI) was conducted through a systematic and collaborative process involving the consultant team alongside key stakeholders, including the Nepal Electricity Authority (NEA) and other relevant entities. The initial planning phase encompassed comprehensive scoping of the subject matter, drafting, and establishing the regulatory framework for EV PCI. This was followed by an extensive development phase, which involved a thorough desk study and literature review to evaluate existing systematic reviews and their adequacy. Key reference materials included the Electricity Grid Code (April 2023), specifically Chapter 4 addressing performance standards for the grid and power quality; the Electricity Regulation 2050 (1993), focusing on voltage, frequency, and power factor requirements as detailed in Schedules 41 through 44; and India's Technical Standards for Connectivity to the Grid Regulations (2019). Additionally, various national and international papers relevant to grid connectivity and performance standards were reviewed to ensure alignment with global best practices. The insights and findings derived from these activities were consolidated into an Interim Phase I Report, which was submitted by WECS in collaboration with the consultant team and stakeholders. This report serves as a foundational document guiding the ongoing refinement of EV PCI regulations to ensure technical robustness, regulatory compliance, and harmonization with international standards.

### **3.5 STANDARDS/SPECIFICATIONS OF EQUIPMENT/PRODUCTS TO BE USED IN EVCS/PCI**

The methodology that has been adopted is as follows:

The development of standards and specifications for Electric Vehicle (EV) Power Charging Infrastructure (PCI) was undertaken through a structured and collaborative process involving the consultant team and key stakeholders, including the Nepal Electricity Authority (NEA) and other relevant agencies. The planning phase focused on scoping the subject, drafting, and establishing the standards and specifications to be applied within the EV PCI framework. This was followed by a comprehensive development phase, which included a detailed desk study and literature review to assess existing systematic reviews and their adequacy. The review encompassed international standards such as IS (Indian Standards), ISO (International Organization for Standardization), and IEC (International Electrotechnical Commission) standards related to charging devices, charging stations, and associated accessories. Additionally, careful consideration was given to the selection of products for EV PCI, emphasizing device interoperability and identifying the responsible agencies for certification and regulation. The outcomes of these activities were compiled and presented in the Interim Phase I Report, submitted jointly by WECS, the consultant team, and stakeholders. This report provides a critical foundation for the finalization of standards and specifications, ensuring

alignment with international best practices and facilitating seamless integration within the national EV charging ecosystem.

### **3.6 SPECIFICATION FOR THE FAST AND SLOW CHARGING AND AC/DC CHARGER**

The methodology that has been adopted is as follows:

The development of specifications for fast and slow charging, including AC and DC chargers, was carried out through a comprehensive and collaborative process involving WECS, the consultant team, and key stakeholders such as the Nepal Electricity Authority (NEA) and other relevant entities. The planning phase involved detailed scoping of the topic, followed by drafting and formulation of the technical specifications to ensure clarity and applicability within the EV charging infrastructure. During the development phase, an extensive desk study and literature review were conducted to evaluate existing systematic reviews and their adequacy. Key reference materials included technical documentation such as Figure No. 1, which provides an overview of the EV charging process, and specific technical details from sections 2.1.4 and 2.1.6 related to charging stations. Additional relevant materials were also reviewed to ensure a comprehensive understanding of the technical requirements. The findings and preliminary conclusions from these activities were compiled into the Interim Phase I Report, which was submitted by WECS in coordination with the consultant team and stakeholders. This report serves as a foundational document guiding the refinement and finalization of specifications for both fast and slow charging technologies within the national EV PCI framework.

### **3.7 DATA COLLECTION, FIELD VISIT AND QUESTIONNAIRE SURVEY**

Collecting accurate and comprehensive data was essential for preparing an effective master plan for public electric vehicle charging stations (EVCS). Both primary and secondary data were systematically gathered from a range of sources to ensure a robust planning foundation.

#### **A. Primary Data Collection**

Primary data collection was conducted to gather original and firsthand information essential for the development of the Electric Vehicle Charging Station (EVCS) Master Plan. This process aimed to provide accurate, location-specific data to support effective planning and implementation.

The data collection activities included:

- **Field Assessments:** Evaluations were carried out to assess the capacity and stability of the existing electricity distribution network, as well as the suitability of potential sites for charging stations.
- **Surveys and Public Engagement:** Surveys were administered to understand community usage patterns of electric vehicles and preferences for charging station locations.
- **Site Inspections:** Physical and technical requirements of selected sites were documented through on-site visits, supported by photographs and digital records.

- **Mapping and Feedback Tools:** Interactive tools were used to collect spatial data on preferred locations for charging infrastructure.
- **Stakeholder Interviews/ Questionnaires Survey:** Consultations with utility providers, local authorities, and potential users were conducted to gather qualitative insights. The sample of Questionnaires survey is present in section 3.9.

Official requests letter was sent to relevant office to obtain information on available government or lease land at proposed sites.

## B. Secondary Data Collection

Secondary data were collected from credible and authoritative sources, supporting the primary data and enriching the analysis. The process included:

- **Identifying Data Requirements:** Data needs were defined based on research objectives.
- **Gathering Data:** Information was collected from government reports, academic journals, international databases, and official online platforms.
- **Cross-Verification:** Data from multiple sources were cross-checked for accuracy and consistency.
- **Systematic Organization:** All data were documented with proper citations for further analysis.

Detailed description of secondary data and its sources is listed below.

Data Description	Data Format	Resolution	Data Source	Remarks
Administrative Boundary (Municipal, District)	Polygon	–	Survey Department of Nepal	<a href="https://www.dos.gov.np/">https://www.dos.gov.np/</a>
Multispectral Satellite Imageries (LULC, Vegetation) (GV)	Raster	$\geq 30 \text{ m} \times 30 \text{ m}$	ESRI	<a href="https://livingatlas.arcgis.com/landcover/">https://livingatlas.arcgis.com/landcover/</a>
Digital Elevation	Raster	$\geq 30 \text{ m} \times 30 \text{ m}$	Earth Explorer	<a href="https://earthexplorer.usgs.gov/">https://earthexplorer.usgs.gov/</a>
Land Slope (LS)	Raster	$\geq 30 \text{ m} \times 30 \text{ m}$	Earth Explorer	<a href="https://earthexplorer.usgs.gov/">https://earthexplorer.usgs.gov/</a>
Land Value	Attribute	–	Department of Land Management and Archive	<a href="https://dolma.gov.np/">https://dolma.gov.np/</a>
Petrol station (PS)	Point	–	OSM, Humanitarian Data Exchange	<a href="https://download.geofabrik.de/asia/nepal.html">https://download.geofabrik.de/asia/nepal.html</a> <a href="https://data.humdata.org/">https://data.humdata.org/</a>

Data Description	Data Format	Resolution	Data Source	Remarks
Transportation Station (TS)	Point	–	OSM, Humanitarian Data Exchange	<a href="https://download.geofabrik.de/asia/nepal.html">https://download.geofabrik.de/asia/nepal.html</a> <a href="https://data.humdata.org/">https://data.humdata.org/</a>
Income Rate (IR)	Attribute	–	National Statistics Office	<a href="https://nsonepal.gov.np/">https://nsonepal.gov.np/</a>
Road Network (RN)	Line	–	Department of Road	<a href="https://www.dor.gov.np/">https://www.dor.gov.np/</a>
Population Density (PD)	Attribute	–	National Statistics Office	<a href="https://nsonepal.gov.np/">https://nsonepal.gov.np/</a>
Junction Nodes (JN)	Line	–	Department of Road	<a href="https://www.dor.gov.np/">https://www.dor.gov.np/</a>
Power Cut area (PC)	Attribute	–	Nepal Electricity Authority	<a href="https://www.nea.org.np/">https://www.nea.org.np/</a>
Electric Vehicle Ownership (EVO)	Attribute	–	Shipping Office, Department of Transport Management	<a href="https://nso.gov.np/">https://nso.gov.np/</a> <a href="https://www.dotm.gov.np/">https://www.dotm.gov.np/</a>
Water Bodies (WB)	Raster	≥ 30 m×30 m	ESRI	<a href="https://livingatlas.arcgis.com/landcover/">https://livingatlas.arcgis.com/landcover/</a>
Landslide Risk zone (LRS)	Point	–	Bipad portal, Humanitarian Data Exchange	<a href="https://bipadportal.gov.np/">https://bipadportal.gov.np/</a> <a href="https://data.humdata.org/">https://data.humdata.org/</a>
Earthquake Zone (EQZ)	Attribute	–	Bipad portal, Humanitarian Data Exchange	<a href="https://bipadportal.gov.np/">https://bipadportal.gov.np/</a> <a href="https://data.humdata.org/">https://data.humdata.org/</a>
Existing Electric Vehicle Charging Station (EVCS)	Point	–	Nepal Electricity Authority	<a href="https://www.nea.org.np/">https://www.nea.org.np/</a>

Note:

SRTM – Shuttle Radar Topography Mission  
DOLMA – Department of Land Management and Archive  
MOLCPA – Ministry of Land Management, Cooperatives and Poverty Alleviation  
NEA – Nepal Electricity Authority, OSM – Open Street Map

#### Key Data Considerations

- **Traffic Volume and Density:** Traffic volume data assists in identifying areas with high vehicular movement, such as major roads, highways, or busy intersections. These locations are prime spots for installing charging stations as they cater to a large

number of vehicles, potentially increasing the accessibility and utilization of the charging infrastructure. The traffic volume data is taken through Department of Roads, DoR.

- **Geographic Data:** Road Networks: Information on road types, traffic flow, and major routes to identify areas with high traffic and potential demand for charging stations.
- **Land Use Data:** Identify land zoning, commercial hubs, residential areas, and areas of interest where EV owners frequently travel.
- **Demographic Data:** Population Density: Data on the population density of different areas helps to predict potential demand for charging stations.
- **Transportation Patterns:** Commuting habits, average travel distances, and transportation modes used by the population in different areas.
- **EV Ownership and Usage Data/ Number of EV Registrations:** Gather information on the number and distribution of registered electric vehicles within the target region. Charging Behavior: Data on charging habits, including preferred charging times, duration, and frequency of charging sessions, if available.
- **Existing Public Charging Stations:** Existing charging stations help to identify, underserved areas lacking sufficient charging options, guiding the placement of new stations to fill these gaps. Analyzing the distribution of existing charging stations helps in avoiding unnecessary duplication or clustering of charging infrastructure in already well-covered areas. The master plan can focus on areas where charging facilities are sparse or absent, ensuring equitable distribution across the region and can address the demand for fast-charging stations in locations where existing infrastructure might have limitations in charging speed. Analyzing usage data from existing charging stations provides insights into charging patterns, peak usage times, and popular locations for EV owners. This data assists in forecasting demand for new stations and determining the optimal locations and charging capacities required to meet evolving user needs.
- **Infrastructure and Power Supply:** Location-wise capacities of existing 33/11kV substation and 33kV & 11kV distribution line different parameters to assess the feasibility of selected location of charging station connecting to the power grid as per the Table 8 and Table 9.
- **Consumer Behavior and Market Research/ Surveys and Feedback:** Conduct surveys or gather feedback from potential EV owners or current users to understand their preferences for charging locations and requirements. Market Trends: Analyze market trends, forecasts, and reports related to EV adoption and charging infrastructure development.
- **Future Development Plans: Urban Development Plans:** Information on future urban development projects or changes in infrastructure that might impact transportation patterns and demand for charging stations.
- Other remaining data were extracted from the online sources for GIS mapping.

### 3.8 STAKEHOLDER ENGAGEMENT

Stakeholder engagement is a critical aspect of developing a Master Plan for Public Charging Infrastructure on National Highways. Engaging with stakeholders help gather diverse

perspectives, insights, and expertise, ensuring that the final plan is comprehensive, feasible, and well-supported. Key Stakeholders for the project are

- Government Agencies: Water and Energy Commission Secretariat, Nepal Electricity Authority, Ministry of Physical Infrastructure and Transport, Department of Transport Management, Ministry of Finance, Ministry of Federal Affairs and General Administration, Provinces/ Municipalities, Department of Customs, Ministry of Industry, Commerce and Supplies / Nepal Bureau of Standards & Metrology (NBSM)
- Private Sectors: EV suppliers, Data centers, Operators of existing charging station
- Electric Vehicle Association of Nepal

Consultative meetings, focus group discussions, and one-on-one interviews were organized to gather insights, concerns, and suggestions. Invitations and briefing materials were shared in advance to facilitate meaningful participation. Feedback from stakeholders was documented, analyzed, and incorporated into the planning and decision-making process to enhance the relevance and acceptance of the project outcomes.

### 3.9 QUESTIONNAIRE SURVEY FOR STAKEHOLDERS

The questionnaire survey was designed to gather insights from various stakeholders involved in the EV ecosystem. The survey included sections tailored to specific groups:

- **Experts:** Questions focused on technical aspects, such as grid connectivity, power factor, and load factor, as well as emerging trends in EV infrastructure.
- **EV Owners/ Users:** Questions related to user behavior, EV usage patterns, charging frequency, and experiences with current charging infrastructure.
- **Suppliers:** Questions about the supply chain, availability of EVs, and challenges related to EV adoption.
- **Charging Station Owners:** Questions about the operation, capacity, and technical aspects of existing charging stations.

The survey was distributed using a combination of online platforms (e.g., Google Forms, email surveys) and in-person interviews at relevant locations (e.g., EVCS, trade events).

#### Questionnaire Survey

Questionnaire survey were conducted to gather primary data using the structured questionnaire to

- A. EV/Manufacturer Supplier      B. Experts      C. EV User

#### Selection of Major National Highways for preparation of Master plan for public charging infrastructure for electric vehicle

S.N.	Criteria
A	POPULATION DENSITY
B	TRAFFIC VOLUME
C	ACCESSIBILITIES TO CITIES
D	EXISTING PETROL STATIONS/CHARGING STATIONS
E	INDUSTRIES/AMENITIES/TOURISM/HISTORICAL/RELIGIOUS CENTRE
F	INFRASTRUCTURE AND POWER SUPPLY AVAILABILITY

S.N.	Criteria
G	FUTURE DEVELOPMENT POTENTIAL
H	PUBLIC FEEDBACK AND DEMAND ANALYSIS

**Information on Rating Scale:**

Rating Scale	Definition
1	Equal important
2	Between the equal and slightly important
3	Slightly important
4	Between the slightly important and strongly important
5	Strongly important
6	Between the strongly important and very strongly important
7	Very strongly important
8	Between the very strongly important and extremely important
9	Extremely important

A. How much do you give importance to **Population Density** with respect to following attributes?

Population Density								Traffic Volume								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Population Density								Accessibilities to cities								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Population Density								Infrastructure and Power Supply Availability								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

B. How much do you give importance to **Traffic Volume** with respect to following attributes?

Traffic Volume								Accessibilities to cities								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Traffic Volume								Infrastructure and Power Supply Availability								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C. How much do you give importance to **Accessibilities to cities** with respect to following attributes?

Accessibilities to cities								Infrastructure and Power Supply Availability								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Signature of Expert: .....

Date: .....

**GOVERNMENT OF NEPAL**  
**WATER AND ENERGY COMMISSION SECRETARIAT**  
**MASTER PLAN FOR PUBLIC CHARGING INFRASTRUCTURE (PCI) ON MAJOR**  
**NATIONAL HIGHWAYS FOR ELECTRIC VEHICLES (EV)**

**QUESTIONNAIRE SURVEY**

**Name of Expert:**

**Organization:**

**Post:**

**Location Selection of Electric Vehicle Charging Station for preparation of Master plan for public charging infrastructure for electric vehicle**

S.N.	Criteria
A	GREEN AREAS/VEGETATION
B	LAND SLOPE
C	LAND VALUES
D	PETROL STATIONS
E	TRANSPORTATION STATIONS
F	INCOME RATE
G	ROAD NETWORK
H	POPULATION DENSITY
I	JUNCTIONS (NODES)
J	DISTANCE TO POWER CUT AREA
K	ELECTRIC VEHICLE OWNERSHIP
L	WATER BODIES
M	LANDSLIDE RISK ZONE
N	EARTHQUAKE ZONE
O	EXISTING ELECTRIC VEHICLE CHARGING STATION

**Information on Rating Scale:**

Rating Scale	Definition
1	Equal important
2	Between the equal and slightly important
3	Slightly important
4	Between the slightly important and strongly important
5	Strongly important
6	Between the strongly important and very strongly important
7	Very strongly important
8	Between the very strongly important and extremely important
9	Extremely important

A. How much do you give importance to **Green Areas/Vegetation** with respect to following attributes?

Green Areas/Vegetation									Land Slope							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Green Areas/Vegetation									Land Values							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Green Areas/Vegetation									Existing Petrol Stations							

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Income Rate</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Road Network</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Transportation Stations</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Population Density</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Junctions (Nodes)</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Distance to Power Cut Area</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Electric Vehicle Ownership</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Water Bodies</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Landslide Risk Zone</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Earthquake Zone</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Green Areas/Vegetation</b>									<b>Existing Charging Station</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

B. How much do you give importance to **Land Slope** with respect to following attributes?

<b>Land Slope</b>									<b>Land Values</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Existing Petrol Stations</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Income Rate</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Road Network</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Transportation Stations</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Population Density</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Junctions (Nodes)</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Distance to Power Cut Area</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Electric Vehicle Ownership</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

<b>Land Slope</b>									<b>Water Bodies</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Landslide Risk Zone</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Earthquake Zone</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Existing Charging Station</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

C. How much do you give importance to **Land Values** with respect to following attributes?

<b>Land Values</b>									<b>Existing Petrol Stations</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Values</b>									<b>Income Rate</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Values</b>									<b>Road Network</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Values</b>									<b>Transportation Stations</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Values</b>									<b>Population Density</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Values</b>									<b>Junctions (Nodes)</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Values</b>									<b>Distance to Power Cut Area</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Values</b>									<b>Electric Vehicle Ownership</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Slope</b>									<b>Water Bodies</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Values</b>									<b>Landslide Risk Zone</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Values</b>									<b>Earthquake Zone</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Land Values</b>									<b>Existing Charging Station</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

D. How much do you give importance to **Existing Petrol Stations** with respect to following attributes?

<b>Existing Petrol Stations</b>									<b>Income Rate</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Existing Petrol Stations</b>									<b>Road Network</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Existing Petrol Stations</b>									<b>Transportation Stations</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Existing Petrol Stations</b>									<b>Population Density</b>							

9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Existing Petrol Stations</b>									<b>Junctions (Nodes)</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Existing Petrol Stations</b>									<b>Distance to Power Cut Area</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Existing Petrol Stations</b>									<b>Electric Vehicle Ownership</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Existing Petrol Stations</b>									<b>Water Bodies</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Existing Petrol Stations</b>									<b>Landslide Risk Zone</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Existing Petrol Stations</b>									<b>Earthquake Zone</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
<b>Existing Petrol Stations</b>									<b>Existing Charging Station</b>							
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Signature of Expert: .....

Date: .....

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**GOVERNMENT OF NEPAL**  
**WATER AND ENERGY COMMISSION SECRETARIAT**  
**PREPERATION OF MASTER PLAN FOR PUBLIC CHARGING INFRASTRUCTURE (PCI) ON**  
**MAJOR NATIONAL HIGHWAYS FOR ELECTRIC VEHICLES (EV)**  
**(Questionnaire Survey for EV Owner/User)**

Name of respondent:

Gender:

Age:

Location:

Occupation:

1. What type of EV do you use?

- 2W (Bike/Scooty)     3W (Auto Rickshaw/tampoo)     4W (Car/Micro)  
 4W (Bus/Minibus)



2. What are the main reason that you prefer an EV? Choose upto 3,

- Capital Cost     Running Cost     Environment Issues     Intelligent function  
 Access to Charge Points     Number of Available Charge Points

3. What is the main use of your Electric Vehicle?

- Going to work on weekends .....km  
 Drive to public transport .....km  
 Around town during the day .....km  
 For Trips .....km  
 Only a few times per week .....km  
 Only weekends .....km  
 Others .....km

4. What is your average mileage of your EV per kWh (unit per km)

- In Plain area.....km/kwh 
- In Hilly area..... km/kwh
- a. Steep Road.....km/kwh 
- b. Slope Road.....km/kwh

5. Do you have home charger?

- Yes                       No

6. What type of charger do you use to charge your EV?

Type A (1kW-3kW, AC)     Type B (7kW-22kW, AC)     Type C (20kW -60kW, DC)

6.What type of charging connector do you use to charge your EV?

GB/T     CHaEdemo     CCS     Tesla     Others

7.Do you think there are enough charging points?

Yes                       No

8.How often do you charge your EV?

Everyday     few times a week     Once a month     few times a month

9.How long have you been using an EV?

1 year     2 year     3 year     4 years+

10.Where do you typically charge your EV?

Home     Work place/Office     Public Charging Station     Others

11.Do you think EV are well popular to the public?

Yes     No

12.Why do you prefer DC fast charging?

- .....
- .....
- .....

13. Which National Highways of Nepal have you travelled?

SN	Name of Highways	Very Important	Important	So-so	Less important	Not Important
1		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Signature of User: .....

Date: .....

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**WATER AND ENERGY COMMISSION SECRETARIAT  
GOVERNMENT OF NEPAL**

**PREPERATION OF MASTER PLAN FOR PUBLIC CHARGING INFRASTRUCTURE (PCI) ON  
MAJOR NATIONAL HIGHWAYS FOR ELECTRIC VEHICLES (EV)**

**(Questionnaire Survey for EV Charging Station Owner/User)**

Name of Respondent (optional):

Gender:

Age:

Location:

Occupation:

Q. What type of EV Charging station you have installed at NHW/Urban Area?

- Public Charging station
- Semipublic Charging station
- Private Charging station
- If any others. ....

Q. What type of EV Chargers you installed in your EV Charging station?

- AC, Type -2 ..... kW ..... no & ..... no. of Gun
- DCFC, GB/T..... kW ..... no & ..... no. of Gun
- DCFC, CCS-1 ..... kW .....no & ..... no. of Gun
- DCFC, CCS-2 ..... kW ..... no & ..... no. of Gun
- DCFC, CHAdeMO ..... kW ..... no & ..... no. of Gun
- DCFC, Tesla..... kW..... no & ..... no of Gun
- If any others .....
- .....

Q. What type and how many of EV, you have charged/Penetration in your EV Charging station every day?

- Car, ..... no.
- Microbus, ..... no.
- Van, Pickup ..... no.
- Minibus ..... no
- If any others ..... no.

Q. How many charging cost you collect from EV Users /kWh or unit?

- NRs ..... Kwh or unit.

---

Q. What are the expenditure for operation and maintenance of EV Charging station/months?

- NRs .....

Q. Are you interested to say something about per kWh /unit rate or Tariff for EV Charging station fixed by NEA/ERC is sufficient for recovery the capital, operation and maintenance of EV Charging Station?

- If yes, give opinions .....

.....

- If no, give opinions .....

.....

Q. What type of problem are you facing to operate the EV Charging Station?

- Not sufficient EV Vehicle flow in the EV Charging station
- EV charger has not properly work
- Power supply cut-off time to time
- EV charging station has not own mobile apps for proper information of EV Owners/ Users.
- If any others .....
- .....
- .....

Q. What type of solution you are feeling to solve the problem of EV Charging Station?

- Dedicated feeder power supply is needed
- EV charger compulsory link with mobile apps for proper information of EV Owners/ Users
- Every 25 to 100 km distance should have one EVCS on the NHW.
- Every 3 to 5 km distance should have one EVCS in the Urban area.
- If any others opinions .....
- .....
- .....

Q. In your opinion Common type of Charging Station fit for all Company vehicles is beneficial?

a) Yes

b) No

Q. How the Charging Station can be made common so that vehicles from many company can be charged?

- a) To need change in socket of charging gun.
- b) To need change in common type of paying apps
- c) Both a & b

Signature of User: .....

Date: .....

**WATER AND ENERGY COMMISSION SECRETARIAT  
GOVERNMENT OF NEPAL  
PREPERATION OF MASTER PLAN FOR PUBLIC CHARGING INFRASTRUCTURE (PCI) ON  
MAJOR NATIONAL HIGHWAYS FOR ELECTRIC VEHICLES (EV)**

Name of respondent:

Contact No

EV Supplier (Company Name)

Location

**Q. General Information of the vehicle**

S.No	Segment of Evs	Company Name/Model	Battery ( Kwh)	Millage/Range (Km/h)	Motor Capacity	Max. Speed (Km/h)	Rating of peak power	Country of Origin	Rate's
1	Buses								
2	Minibuses								
3	Microbuses								
4	Cars								
5	Three Wheelers								
6	Two Wheelers								

**Questions**

.....

2. Is Electric Vehicle still in testing phase?

.....

3. Future improvements in the battery/motor capacity?

.....

4. In your opinion Common type of Charging Station fit for all Company vehicles is beneficial?

a) Yes

b) No

5. How the Charging Station can be made common so that vehicles from many company can be charged?

- a) To need change in socket of charging gun.
- b) To need change in common type of paying apps
- c) Both a & b

Signature of User: .....

Date: .....

### 3.10 ASSESS THE AVAILABILITY OF SUITABLE LAND/ LOCATION AND THE APPROPRIATE MODE OF OBTAINING LAND

After the appropriate location selection of EVCS, the Consultant with the support from WECS, the letter was written to the concerned Municipality (which fall under the selected EVCS) to obtain the land as leasing or public place.

After selection of location of charging stations along the National Highways, WECS informed/ notified through the official letter to related Municipalities/District Office of Survey for required government land and/or lease land to establish EV PCI.

### 3.11 ASSESSMENT ROAD GRADIENT ON THE MILEAGE OF EVS WHILE ACCESSING THE LOCATION OF THE CHARGING INFRASTRUCTURES

After the appropriate location selection of EVCS on the selected Highway, the Consultant will monitor the reduced level at the prominent location of the site visited Highway, also comparing the data with the Google Earth mapping work of the Highway as per the table below.

Parameter	Symbol	Formula / Description	Unit
Road Gradient	G	$\frac{\text{Elevation Change}}{\text{Horizontal Distance}} \times 100$	% (slope)
Incline Angle	$\theta$	$\tan^{-1}(G)$	degrees ( $^{\circ}$ )
Vehicle Mass	m	Given vehicle mass	kg
Gravitational Force	Fg	$mg \sin(\theta)$	N (Newton)
Rolling Resistance	Fr	$C_r mg \cos(\theta)$	N
Aerodynamic Drag	Fa	$\frac{1}{2} C_d \rho A v^2$	N
Total Force	Ftotal	$F_g + F_r + F_a$	N
Power Demand	P	$F_{\text{total}} \times v$	W (Watts)
Regenerative Power	Pregen	$\eta_{\text{regen}} mg \sin(\theta) v$	W (Watts)
Energy Consumption	E	$\frac{P}{V}$	Wh/km

### 3.12 ASSESSMENT OF CAPACITY OF THE DISTRIBUTION NETWORK/ STABILITY & ADEQUACY OF THE POWER SOURCE CONNECTING TO THE GRID

The assessment process for evaluating the capacity of the distribution network and the stability and adequacy of the power source connecting to the national grid was implemented through a structured and collaborative approach. Initially, during the planning stage, the team undertook comprehensive scoping of the key topics and systematically developed assessment frameworks, as presented in Table 5 and Table 6. This phase ensured that the objectives and criteria for evaluation were clearly defined in alignment with project goals.

In the subsequent development stage, a combination of desk-based research, primary data collection, and field visits was carried out, following the schedule established during Interim

Phase II. These activities enabled the detailed analysis of critical parameters, including network capacity, system stability, and the adequacy of power sources feeding into the grid. Holistic data collection methods ensured that both quantitative and qualitative aspects were diligently captured.

To further enrich the assessment, tailored questionnaires for Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) were developed in close consultation with stakeholders. This approach allowed for the collection of valuable insights and feedback from diverse participants, enhancing the robustness of the evaluation.

Finally, all findings and analyses were synthesized and presented in the Interim Phase II Report. The process involved ongoing engagement with the Water and Energy Commission Secretariat (WECS), the Consultant Team, and stakeholders such as the Nepal Electricity Authority (NEA), ensuring comprehensive review, validation, and a shared sense of ownership over the assessment outcomes.

### **3.13 GRID IMPACT STUDY OF THE HEAVY VEHICLE INTEGRATION**

The grid impact study for the integration of heavy electric vehicles (EVs) was conducted to address the significant challenges posed by their extremely fast charging requirements, which can impose very high charging loads at the multiple-megawatt scale, especially when many vehicles charge simultaneously.

In the planning stage, the Water and Energy Commission Secretariat (WECS), Consultant Team, and key stakeholders, including the Nepal Electricity Authority (NEA), collaboratively scoped the study and identified the critical parameters necessary for assessing the grid impact.

The development phase involved a detailed desk study and review of technical parameters such as harmonics, power factor, and voltage deviation, which are essential components influencing grid stability. Additionally, the team evaluated mitigation measures consistent with the Grid Code to manage these parameters effectively. Based on this technical review and regulatory framework, the Grid Impact Study was finalized, ensuring alignment with national standards and requirements.

Following data synthesis and analysis, the Interim Phase II report was submitted for review by all involved parties. Subsequently, a workshop was organized where the draft report including cost estimations, financial analysis, and an implementation plan was presented to participants and focus groups for technology transfer and to solicit comments and suggestions. These inputs were incorporated into the final draft of the Master Plan for Electric Vehicle Power Charging Infrastructure (EV PCI).

Finally, incorporating feedback from the client and stakeholders, the Final Master Plan for EV PCI was prepared and submitted for approval by WECS, paving the way for informed decision-making and strategic implementation to accommodate the anticipated heavy vehicle charging demands on the grid.

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### **3.14. NATIONAL HIGHWAY AND OPTIMAL LOCATION SELECTION OF EVPCI FOR MASTER PLAN**

The data from different sources are integrated to create a comprehensive dataset. Information on population density, transportation networks, energy infrastructure, and existing charging stations are combined. The consultant ensured that data integration adheres to a common data model for consistency.

#### **3.14.1 Selection of Major National Highway**

The consultant developed weight system on the criteria affecting the selection of EV charging station. The weightage and factors were discussed and finalized by consulting with the client. The criteria that were adopted for the selection of major National Highways are discussed below:

- **Population density**  
Higher population density often correlates with increased vehicles. Areas with dense populations are likely to have more EV owners and potential users, necessitating requirements of charging stations. In densely populated regions, charging stations are likely to experience higher utilization rates.
- **Traffic volume**  
High-traffic areas i.e. busy National Highways are likely to experience increased demand for charging stations. Placing charging stations in these locations ensures they are utilized efficiently. Placing charging stations in locations with high traffic volume helps promote electric vehicle adoption by providing convenient charging options for a broad audience. This can contribute to increased awareness and acceptance of EVs.
- **Accessibilities to cities**  
The charging stations need to be placed at locations which are easily accessible to big cities.
- **Infrastructure and Power Supply Availability**  
The location for public charging stations need to be selected ensuring the local power infrastructure can support the addition load imposed by charging stations.

Other criteria such as Length of Highway, Industries/ Amenities/ Tourism/ Historical/ Religious centre etc. served by roads, Future Development Potential along the road, Public Feedback and Demand Analysis are also some of the defining criteria for NH selection.

Analytic Hierarchy Process (AHP) method was used in this research for selecting highway by comparing the relative importance among the factors affecting EV charging station. In this research, AHP was used in three steps. The first step was identifying the attributes affecting the EV location. The second step was setting relative scores by questionnaire survey for the factors affecting EV location and computing the weights of criteria. In the third and last step, consistency was checked and ranking was computed.

- a) Identifying Attributes and criteria:

Based on the questionnaire survey, important attributes and criteria of road for the selection of EV location are included in this study.

- Population Density
- Traffic Volume
- Accessibility to Cities
- Length of Highway
- Industries/ Amenities/ Tourism/ Historical/ Religious centre etc. served by roads
- Infrastructure and Power Supply Availability
- Future Development Potential along the road
- Public Feedback and Demand Analysis

b) Setting the Relative Scores

It is necessary to calculate how important the criteria are to each other, which is their relative importance. The criteria are compared relative to the importance of determining the priorities. The experts on the subject determine the degree of importance by comparing the criteria at each level in pairs. In this study, the rating range is on a scale of 1 to 9 as suggested by (Saaty, 1990) as shown in table below. The decision-maker determines the degree of importance between the criteria based on the 1–9 scale. The comparison scale developed by Saaty is explained in Table below.

**Table 17: Saaty’s Rating Scale**

Rating Scale	Definition
1	Equal important
2	Between the equal and slightly important
3	Slightly important
4	Between the slightly important and strongly important
5	Strongly important
6	Between the strongly important and very strongly important
7	Very strongly important
8	Between the very strongly important and extremely important
9	Extremely important

c) Preparation of comparison matrix for the determining criteria

The comparison matrix for the determining criteria is shown in Table. In a matrix with n elements, n (n-1)/2 comparisons are made. For example, comparing criteria 2 and 3 were evaluated as “which of these two criteria is more important and how important is it to achieve the goal”.

If opinions are taken from experts in more than one field, a comparison of the binary matrix is taken from each of them separately. Opinions from all experts are collected in a single matrix by taking the geometric mean. The comparison matrix is an n × n square matrix. The matrix components on the diagonal of this matrix take the value 1. In the first stage, the importance level of the pairwise comparison matrix was determined by considering the formulation below. Since the relevant factor is compared with itself, the diagonal of the matrix takes the value of 1.

**Table 18: Comparison Matrix**

	Criteria 1	Criteria 2	Criteria...	Criteria j
Criteria 1	W1/W1	W1/W2	...	W1/Wj
Criteria 2	W2/W1	W2/W2	...	W2/Wj
Criteria...	...	...	...	...
Criteria j	Wj/W1	Wj/W2	...	Wj/Wj

## d) Normalization

The normalization of the pairwise comparison matrix obtained in the second step was made. The following formula was used for normalization.

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}}$$

For the normalization process, the sum of each column is calculated. The elements of each column are obtained by dividing the column-by-column sum. The normalized matrix is:

$$C = \begin{pmatrix} c_{11} & \dots & c_{1n} \\ \dots & \dots & \dots \\ c_{n1} & \dots & c_{nn} \end{pmatrix}$$

## e) Calculating Priority Vector

In calculating the priority vector, the arithmetic average of each row is taken.

$$w_i = \frac{\sum_{j=1}^n c_{ij}}{n}$$

## f) Check Consistency and Ranking

Consistency is the process of checking how logically the respondent has evaluated the factors, and consistency problems may arise in the process of measuring relative weights among the evaluation factors.

Column vector D is obtained from the matrix multiplication of the comparison matrix A and the priority vector w.

$$D = \begin{bmatrix} a_{11} & \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \dots & a_{nn} \end{bmatrix} \times \begin{bmatrix} w_1 \\ \cdot \\ w_n \end{bmatrix}$$

The EI value is calculated by dividing the D column vector/priority vector.  $\lambda_{max}$  is the maximum eigenvalue, which value is obtained from dividing the summation of weight sum of attributes divided by average weight of attributes by number of attributes. Consistency Index

(CI) and Consistency Ratio (CR) can be considered to examine the consistency of questionnaire. They are shown in equations below.

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

$$CR = \frac{CI}{RI}$$

The required RI value is given in Table below.

**Table 19: Random Index Value**

<b>N</b>	1	2	3	4	5	6	7	8	9	10
<b>Random index (RI)</b>	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The higher the consistency index, the value gets closer to 0. If the consistency ratio is less than 0.1 (10%), it means respondents answered consistently. Otherwise, it means the opposite and excluded from the survey.

g) Identifying alternatives

All alternatives are compared for each criterion. The value of comparing alternatives with each other is 1. Experts will be asked to compare the alternatives, and the final value will be obtained by taking the geometric mean.

In order to familiarize the client and other related stakeholders regarding the concept and idea of AHP method for selection of National Highways, the consultant team will conduct the pilot test of this method for a particular section of any selected section of Highway before conducting selection of locations of EVCS and this which will be demonstrated to collect required reviews so that it could be incorporated in further stages.

**3.14.2. Locating EV charging station**

The criteria to be adopted for locating EV charging stations were discussed and finalized by consulting with the client. The criteria are as follows:

- **Population Density:** The necessity for charging stations is greater in areas where electric vehicles are frequently used. For this reason, population density can be used as a factor to determine these regions. In this study, the up-to-date population data of each neighborhood of selected road will be used from CBS data. Higher the population density, location will be more suitable for charging station.
- **Roads:** The roads that are often used by electric vehicles are critical in order to determine suitable locations of electric vehicle charging stations. Focus on roads with

two or more lanes to create a vector map layer. Proximity to well-used roads is considered crucial for determining suitable charging station locations.

- **GDP:** Creation of a map layer based on GDP rate of the district to consider economic factors. The areas featuring a high-GDP rate are considered more suitable for charging stations.
- **Industries/ Amenities/ Cultural/ Historical/ Religious/ Tourism center** served by roads Public charging stations for electric vehicles (EVs) are strategically located to serve various industries, amenities, cultural and historical sites, religious centers, and tourism destinations. Placing charging stations in these locations ensures that electric vehicle users have convenient access to charging infrastructure.
- **Existing Petrol Stations:** Existing petrol stations are the potential locations for electric vehicle charging stations. The existing petrol stations can be considered as suitable locations for electric vehicle charging stations because these areas are located according to the current traffic network. If the location is close to petrol stations, it will be more suitable.
- **Existing charging stations:** The new charging stations will be selected keeping in mind the location of existing charging stations.
- **Parking Areas:** The parked cars can be efficiently charged. If the location is at the parking areas, it will be more suitable.

The current and future demand for EV charging in the highway were determined. This was done by using data sources such as vehicle registration, surveys, travel patterns, and projections of EV market share and adoption rates.

This step is to identify the best locations for EV charging stations based on factors such as accessibility, visibility, availability, compatibility, and safety. You can use tools such as geographic information systems (GIS), which can map and analyze spatial data and criteria related to EV charging. For example, you can use GIS to identify potential sites that are close to major roads, attractions, amenities, and parking facilities, as well as to avoid sites that are prone to congestion, flooding, or vandalism.

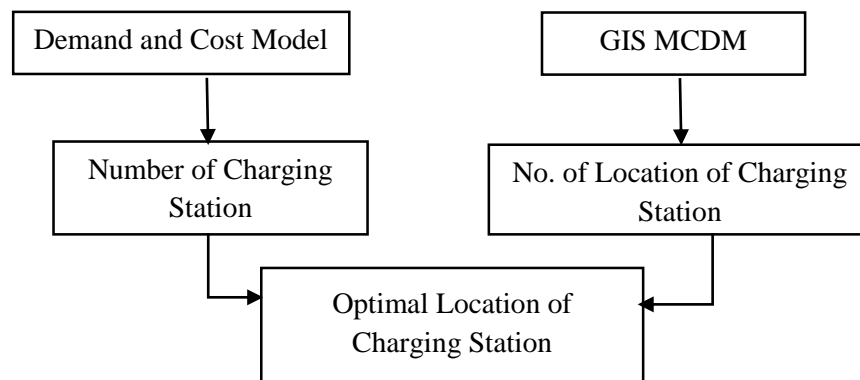
The methodology consists of three parts.

- i. Demand and Cost Model
- ii. GIS MCDM method
- iii. Optimal Location

Demand and cost model use energy demand, investment, and operation cost of charging station to determine the number of charging station required along the Highway.

GIS MCDM method was used to identify the location of charging station by evaluating the parameters such as supply criteria (the availability of electricity connections and charging network, parking location or existing petrol station), demand factors such as the attractiveness of each location population etc.

Cluster analysis were performed to ensure a convenient and reliable geographic coverage rather than concentrating the charging stations in profitable areas. Second, as an attempt to reduce the public charging access gap for underserved communities with more equitable distribution across the clustered areas within the municipality.



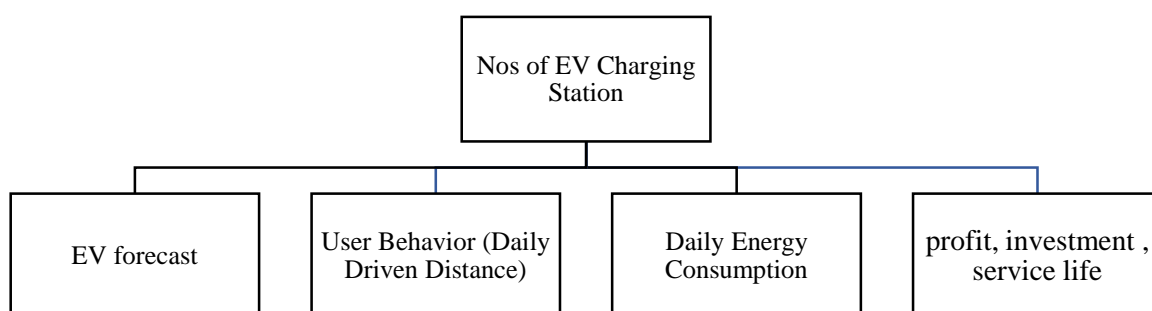
EV growth rate in Next 5 Years

Forecasting the growth of electric vehicles (EVs) is indeed a critical aspect of planning the placement of charging stations. Gather historical data on EV sales and adoption rates from reliable sources such as government agencies, industry reports, and academic studies. Analyze trends in EV sales, market share, and adoption patterns to understand past growth rates and factors influencing EV uptake.

Develop multiple scenarios representing different potential futures for EV growth. Consider optimistic, pessimistic, and moderate scenarios to account for uncertainty and variability in future outcomes. The required number of the charging station under these situations were determined.

**3.14.3 Demand and Cost Model**

To estimate the required number of public charging stations, an approach proposed by Philip and Wiederer and extended by Wirges et al. was adopted in this part. This approach was built upon an energy balance formula combined with a finance model for refinancing public charging stations, as shown in Figure.



Number of the charging stations was decided by estimating total energy consumed by electric vehicle daily and the total energy that could be supplied by the public charging station as given by the following formula as proposed by Khalife, Fay and Gohlich.

$$C_i = \frac{N \cdot e \cdot d \cdot R_i}{p_i \cdot t_c}$$

Where,

$C_i$  = No's of EV charger

$N$  = Nos. of electric vehicles

$e$  = energy consumption of an electric vehicle (kWh/km)

$d$  = daily driven distance (km)

$R_i$  =percentage of consumed energy recharged at charging station

$p_i$  = power of charging station (kW)

$t_c$  = average charging time

$n$  = service life

Marginal profit with average daily charging time 'tc'

$$P = t_c \times m \times p_i \times 365$$

Where,

$m$  = marginal profit between charging price and electricity cost over the daily charging time 'ti'

To achieve economic feasibility, it is required that the actual generated yearly profit equals or exceeds the expected yearly profit

$P$  (marginal yearly profit) >  $A$  (annualized cost of investment)

the ideal case would be to invest in a charging station that can generate profit only to repay itself over service life.

$$A = \frac{C}{n}$$

'n' = service years

$$P \geq A = \frac{C}{n}$$

$$t_c \times m \times p_i \times 365 = \frac{C}{n}$$

The minimum average charging time 'tc',

$$t_c = \frac{C}{n \times m \times p_i \times 365}$$

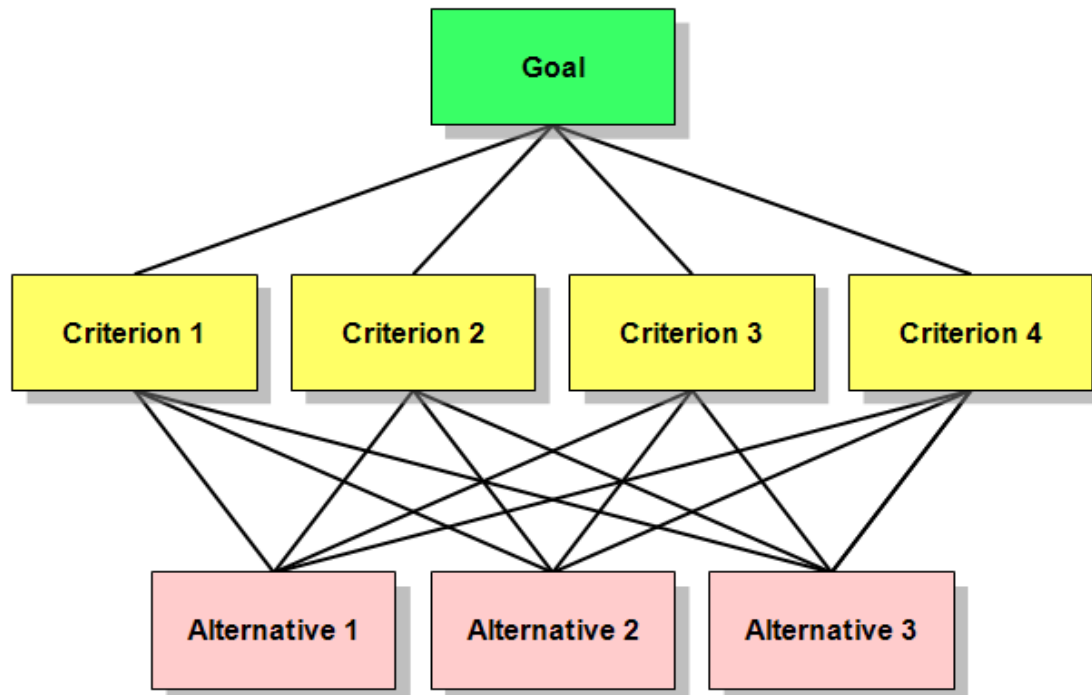
#### **3.14.4. GIS and MCDM method**

Geographic information systems (GIS) employ locational and tabular data, computer hardware, and software to gather, map, and analyze geographically linked data. GIS users may organize, visualize, and analyze several layers of data by creating maps and scenes (Zhao, Gao, & Cheng, 2023). By being able to effectively depict different types of data, users may identify patterns, understand trends, monitor changes, and respond to events, all of which aid in improving decision-making (Science, n.d.). It has numerous applications in a variety of industries, including supply chain management, facilities management, environmental and natural resource management, transportation, insurance, forestry, urban planning, land information systems, engineering, street networks, and many more (Szterlik-grzybek, 2023).

MCDM Techniques for determining the ideal location for putting up electric car charging stations have been more developed over time. Based on the activities involved, the availability of EVs in a particular area, and the expertise of industry experts who looked for the ideal sites to erect EV charging stations, the EVCS was first established using a range of strategies (Guler & Yomralioglu, 2020a). However, Geographic Information System (GIS) and Multi criteria Decision-Making (MCDM) approaches are currently mostly utilized to find places for electric car charging stations due to their effectiveness, accuracy, and reliability in site selection.

#### **Analytical Hierarchy Process (AHP) and Multi-Criteria Decision Analysis (MCDM)**

In the use of multi-criteria decision analysis, flood causal factors were constructed using the analytic hierarchy process, a systematic method for handling difficult issues. In theory, rather than dictating the right course of action, the AHP helps decision makers choose the solution that best fits their requirements and comprehension of the issue (Guler & Yomralioglu, 2020b). This suggests that AHP is a method of decision-making that relies on people's actual capacity for making important choices. The project's objective, in this case land use appropriateness for current and future built-up areas, must be determined in order to conduct the AHP. To rate them appropriately, a variety of criteria or parameters are set. The overall framework of the analytical hierarchy process is depicted in the following figure.



**Figure 14: Analytical Hierarchy Process (AHP)**

Following the creation of the hierarchy, the expert or experts and participants utilize AHP to determine the relative importance of each node in the hierarchy. It's an excellent method for simultaneously collecting and analysing data from participants and experts. The following table illustrates how its design distributes priorities in a hierarchical fashion, with the values of those priorities being established by the data that process users submit. A standardised comparison scale consisting of nine levels serves as the foundation for multiple pairwise comparisons in AHP. A person can regularly rate and compare up to nine items at once, according to psychologists. The finest available information as well as the decision maker's expertise and experience are the foundations of pairwise decisions. A standardised comparison scale consisting of nine levels serves as the foundation for multiple pairwise comparisons in AHP. Psychologists chose that number because people can rate and compare up to nine items at once. The finest available information as well as the decision maker's expertise and experience are the foundations of pairwise decisions. The following lists each of the chosen parameters' relevance level (priority weight).

**Table 20: Priority Weight**

<b>Intensity of importance</b>	<b>Definition</b>	<b>Description</b>
1	Equally important	Two factors contribute equally to the objective.
3	Moderately more important	Experience and judgement slightly favor one over the other.
5	Strongly more important	Experience and judgment strongly favor one over the other.

Intensity of importance	Definition	Description
7	Very strong more important	Experience and judgment very strongly favor one over the other. Its importance is demonstrated in practice.
9	Extremely more important	The evidence favoring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed.
Reciprocal of above	If an element I has one of the above numbers assigned to it when compared with element j, then j has the reciprocal value when compared with i	
Ratios (1.1-1.9)	If the activities(elements) are very close	May be difficult to assign the best value, but when compared with other contrasting activities (elements) the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities (elements).

There are four steps to the AHP process: build a decision tree; determine the relative importance of attributes and sub-attributes; weigh each alternative against each attribute; and verify that the subjective evaluations are consistent. Each alternative is evaluated and its overall weight is calculated. The process of AHP can be summarized in four steps: construct the decision hierarchy; determine the relative importance of attributes and sub-attributes; evaluate each alternative and calculate its overall weight in regard to each attribute, and check the consistency of the subjective evaluations. Let  $C_j = \{c_j \mid j=0,1, \dots, n\}$  be the set of criteria. The result of the pairwise comparison on  $n$  criteria can be summarized in an  $(n \times n)$  evaluation matrix  $A$  in which every element  $a_{ij}$   $\{i, j=0,1,2,3,n\}$  is the quotient of weights of the criteria, as given in Equation (1)

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix}, a_{ii} = 1, a_{ji} = 1/a_{ij}, a_{ij} \neq 0 \tag{1}$$

The relative weights are given by the right eigenvector ( $w$ ) corresponding to the largest eigen value  $\max(\lambda)$  as in Equation (2).

$$Aw = \lambda_{\max} w \tag{2}$$

The final consistency ratio (CR), usage of which lets the user to conclude whether the evaluations are sufficiently consistent, is calculated as the ratio of the CI and the random index (RI), as expressed in Equation (3). The values of RI are tabulated in the following table.

$$CR = CI / RI \tag{3}$$

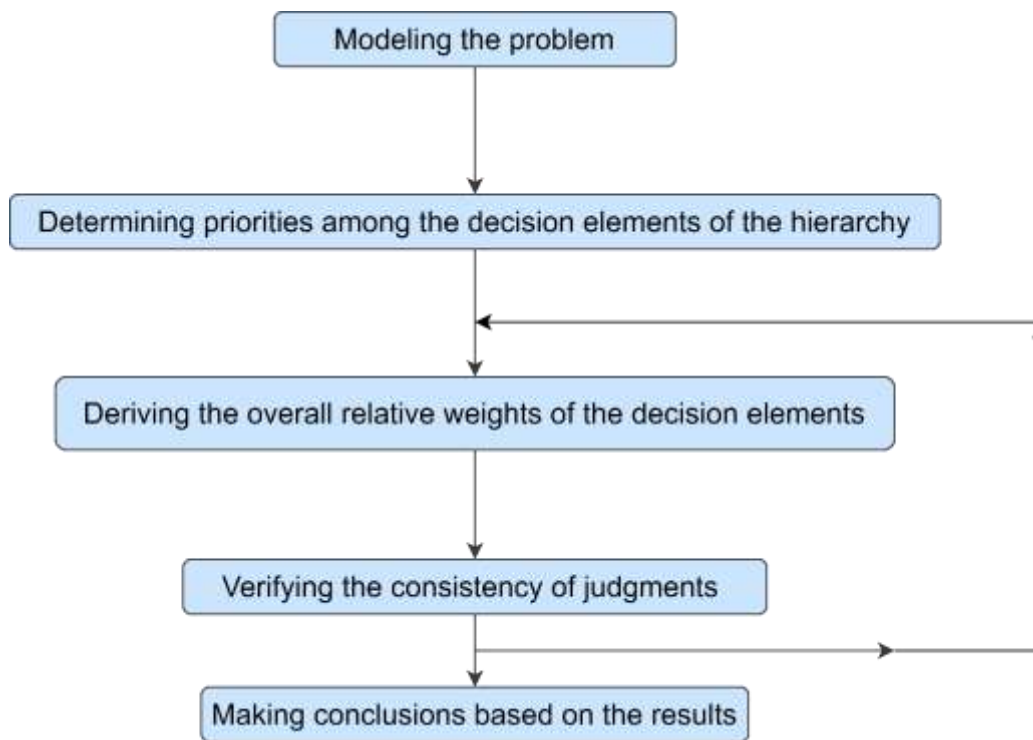
Random index (*RI*) used to compute consistency ratios (*CR*).

**Table 21: Random Index (Saaty)**

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<b>Random Index (RI)</b>	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

In this analysis maximum threshold of the CR is 10 percent, and in case of exceedance a three-step procedure is followed

- i) find the instance where the decision maker's judgment is the most erratic
- ii) determine a range of values to which the inconsistent judgment can be changed in order to reduce the associated inconsistency,
- iii) and ask the decision maker to reconsider the judgment to a "reasonable value."



**Figure 15:AHP steps (Lamichhane, 2022)**

### 3.14.5 Suitability analysis for EVCS

The variables that influence the position of the charging station are chosen by taking into account the results of previous studies. Population density, retail centres, roads, income levels, gas stations, parks, green spaces, slope, and property values are some of these factors. Each criterion and its sub-criteria are thoroughly explained in this section. Additionally, maps representing each criterion's spatial appropriateness distribution were created.

The sub-criteria are listed in Table. The walking distance between the station and the demand point is taken into consideration when calculating the sub-criterion scores of distance-based criteria. It is acknowledged that a distance of fewer than 500 meters is suitable in Nepal (Guler & Yomralioglu, 2020a).

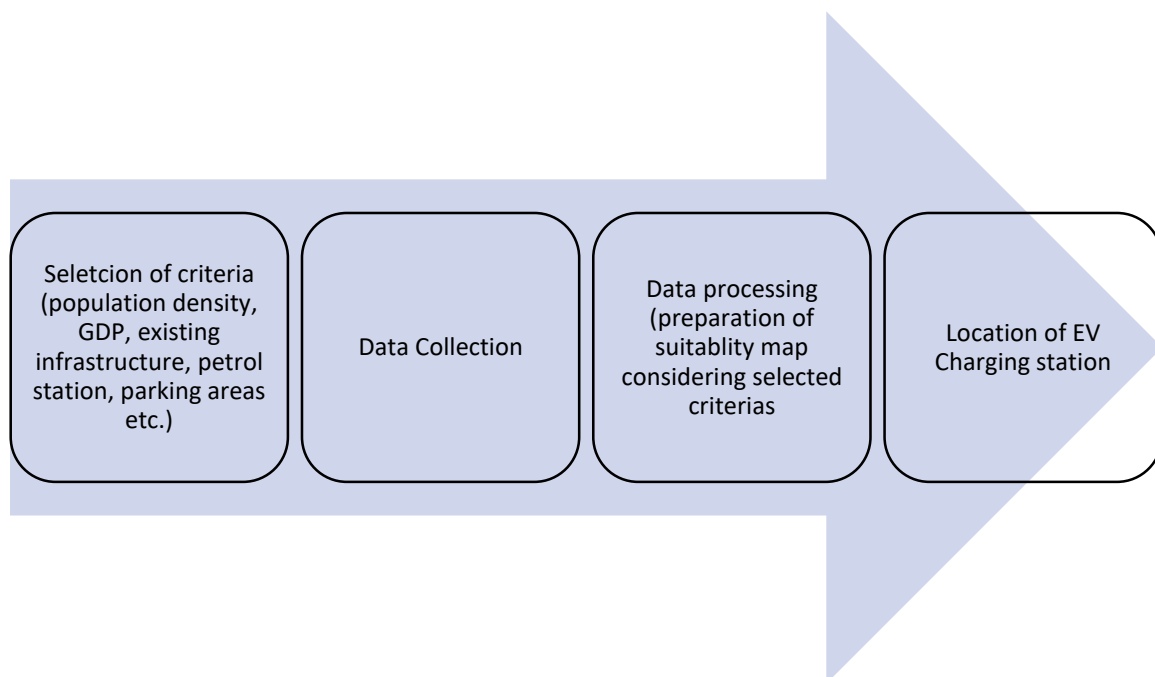
**Table 22: Sub-criteria of EVCS selection**

Main Criteria	S.N	Sub Criteria	Data Sources	Data Format	Resolution
Environmental/ Geographical factor	1.	Distance to Vegetation/Green Areas	Sentinel-2A satellite image	Raster	$\geq 10 \text{ m} \times 10 \text{ m}$
	2.	Distance to water resources	SRTM DEM	Line	-
	3.	Distance to landslide risk	Digitization from Map	Spatial Grid	
	4.	Slope of Land	SRTM 1 Arc Sec DEM	Raster	$\geq 30 \text{ m} \times 30 \text{ m}$
	5.	Earthquake risk	Digitization from Map	Spatial Grid	-
Economic Factor	6.	Land Cost	MOLCPA, DOLMA Statistics	Value/Attribute	-
	7.	Income Rates	Municipal Profiles	Value/Attribute	-
	8.	Electric Vehicle ownership in the service area	Secondary data from the authorize dealer and DOTM	Value/Attribute	-
	9.	Distance to power cut area	Data from NEA	Polygon	-

<b>Main Criteria</b>	<b>S.N</b>	<b>Sub Criteria</b>	<b>Data Sources</b>	<b>Data Format</b>	<b>Resolution</b>
Urbanity Factor	10.	Service area population	Population data from Central Bureau of Statistics (CBS)	Value/Attribute	-
	11.	Proximity to Junctions	Junctions data derived from network analysis from GIS	Point	-
	12.	Transportation Station	Data from Map and OSM	Point	-
	13.	Proximity Road	DOR	Line	-
	14.	Proximity to petrol station	Petrol station data can be derived from digitization and OSM	Point	-
	15.	Distance to other EVCSs	Existing charging station data acquired from NEA	Point	-

In the next step, each suitability index was obtained by applying WLC that can associate each criterion layer to its weight and combine all of them. The common areas associated with each suitability class were found as a means of intersecting each suitability index layer so that the dependableness of the results is enhanced. This process was conducted by means of map algebra and also provides the final suitability index. The alternative locations of charging stations were determined according to the high suitable class of the final suitability index.

In this study, a GIS based MCDM approach was applied to determine suitable locations of electric vehicle charging stations. Since GIS techniques manipulate both spatial data and semantic data, the consultant benefited from them in order to tackle the different complex problems that require spatial data and analyses.



### Selection criteria

The study aims to identify suitable locations for electric vehicle charging stations based on a comprehensive set of criteria. In this work, fifteen criteria are used to select suitable locations of the electric vehicle charging stations. The existing researches are taken into consideration in order to select the criteria that affect the charging station location. These criteria are population density, shopping malls, roads, GDP, petrol stations, park areas, and land values. This section presents the comprehensive explanations of each criterion and its sub-criteria. Also, the maps that represent the spatial suitability distribution of each criterion was produced.

### Preparation of Suitability Maps

Suitability maps in Geographic Information System (GIS) are visual representations that highlight the most suitable areas for a specific purpose based on predefined criteria and factors. The suitability for charging stations differs depending on different criteria. All spatial layers have pixel values between zero and five.

To account for the relative importance of different criteria, weights are assigned to each factor. The GIS analyst may also apply scoring systems to evaluate the degree of suitability or desirability for each criterion.

#### Selection of the Alternative locations

MCDM-based location selection studies: These alternatives are ranked according to their final suitability index values, i.e. their pixel values. Priority Sites for EV locations are aggregated pixel-wise.

The GIS software performs overlay analysis by combining the weighted and scored data layers. This process generates a composite map that indicates the overall suitability of different areas based on the selected criteria.

The output map often classifies areas into suitability classes, such as highly suitable, moderately suitable, and unsuitable. These classes help decision-makers quickly identify areas that align with the specified criteria.

GIS provides tools for visualizing the results. Suitability maps are typically presented using color-coding or shading to highlight different suitability classes. This visual representation makes it easier for stakeholders to interpret and understand the findings.

To familiarize the client and other related stakeholders regarding the concept and idea of this method for selection of Charging Stations, the consultant team conducted the pilot test of this method for a particular section of any selected section of Highway before conducting selection of locations of EVCS and this which was demonstrated to collect required reviews so that it could be incorporated in further stages.

#### **3.14.6 EVCS Station Coding System**

The EVCS station coding format is designed to provide a standardized, scalable, and location-specific identifier for every Electric Vehicle Charging Station (EVCS) across Nepal. The format is:

**EVCS/PDDGNWW/NHN - SN**

where each segment encodes key geographic and infrastructure data.

#### **Format Breakdown**

##### **EVCS**

Denotes the infrastructure as an Electric Vehicle Charging Station.

##### **P–Province Code(1–7)**

Identifies one of Nepal’s seven provinces:

1 = Koshi

2 = Madhesh

3 = Bagmati

4 = Gandaki

5 = Lumbini

6 = Karnali

7 = Sudurpashchim

**DD – District Code (01–77)**

Specifies the district within the province, uniquely identifying one of Nepal’s 77 districts.

**GN – Gaunpalika/Nagarpalika Code (01–N; 99 for conservation areas)**

Represents the local government unit (rural or urban municipality), with the code range corresponding to the number of such units in the district. “99” is reserved for conservation areas.

**WW – Ward Number Code (01–33)**

Indicates the specific ward within the municipality or rural municipality, supporting up to 33 wards.

**NHN – National Highway Number (01–80)**

Identifies the national highway on which the EVCS is located, following the Department of Roads’ latest highway numbering (e.g., NH01 for East-West Highway).

**SN – Station Number**

Sequential identifier for the EVCS along the specified highway:

- Single digit (1–9) if fewer than 10 stations exist on the highway
- Two digits (01–99) if there are 10 or more stations

**Example Interpretation**

**EVCS/3011204/01 - 01**

- EVCS: Electric Vehicle Charging Station
- 3: Bagmati Province
- 01: Kathmandu District
- 12: Kageshwari Manohara Municipality
- 04: Ward No. 4
- 01: National Highway 01 (East-West Highway)
- 01: First EVCS on NH01 at this location

**Purpose and Benefits of the Nomenclature System:**

**Standardization:** Delivers a uniform system for naming and cataloging EV charging infrastructure nationwide.

**Traceability:** Facilitates precise identification, management, and maintenance of each station.

**Scalability:** Supports future expansion across all administrative levels and infrastructure growth.

**Integration:** Enables seamless integration with GIS, asset management, and power grid systems.

**Readability:** Encodes critical geographic and route data in a concise, machine- and human-readable format.

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This coding system ensures each EVCS is uniquely identifiable, traceable, and ready for integration into national infrastructure and digital platforms.

### **3.14.7. Projection of EVs**

#### **a) Business as Usual (BAU)**

The BAU projects future electric vehicle (EV) adoption and energy demand based on current trends, without introducing new policies or interventions. This approach uses historical data on vehicle growth, energy consumption, and existing market dynamics. Tools like the LEAP (Long-range Energy Alternatives Planning) model are commonly used to simulate future scenarios by simply extrapolating past rates of fossil fuel vehicle adoption and energy use. In Nepal's context, BAU assumes continued dominance of internal combustion engine vehicles (ICEVs), minimal policy support for EVs, and limited expansion of charging infrastructure. The result is a projection of rising fossil fuel consumption and greenhouse gas emissions, with energy demand in the transport sector expected to increase significantly by 2045 if no major changes are made.

#### **b) Sustainable Scenario (NDC 3.0)**

The sustainable scenario aligns closely with Nepal's Third Nationally Determined Contribution (NDC 3.0) and long-term climate strategies by incorporating proactive policy measures, targeted infrastructure investments, and behavioral shifts to accelerate electric vehicle (EV) adoption. It projects ambitious government targets, including achieving 25% EV sales by 2025 and up to 90% by 2030, with battery electric vehicles (BEVs) comprising 90-95% of all private passenger vehicles (including two-wheelers), 70-90% of four-wheeler public passenger vehicles, and 10-20% of freight and waste collection vehicles by 2030 and 2035. This scenario leverages fiscal incentives such as reduced import duties and tax breaks, alongside planned expansion of charging infrastructure. Utilizing scenario-based modeling tools like LEAP, combined with stakeholder engagement, policy analysis, and Monte Carlo simulations to address uncertainties, the approach estimates the impacts of these interventions on vehicle sales, electricity demand, and emissions. Furthermore, it emphasizes strategic actions consistent with NDC 3.0, such as allocating pollution tax revenues to EV development funds and subsidizing green loans, to effectively steer Nepal's transport sector toward a sustainable, low-emission future.

#### **c) Net Zero Emission Methodology**

The net zero emission is the most ambitious, aiming for complete decarbonization of the transport sector by a target year (such as 2045). This approach models a phased transition where ICEVs are systematically replaced by EVs, powered primarily by renewable energy (hydropower in Nepal's case). The methodology involves setting strict targets for zero-emission vehicle sales, implementing comprehensive policy packages (e.g., banning new ICEV sales by a certain date, mandating Euro6-equivalent standards), and investing in grid upgrades and charging infrastructure. Modeling tools simulate the impact of these aggressive measures on energy demand, emissions, and economic factors, ensuring projections are consistent with

Nepal's commitments under the Paris Agreement and its Long-Term Strategy for Net-Zero Emissions. The projections are regularly updated with real-world data to track progress and adjust strategies.

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## CHAPTER 4: RESULT ANALYSIS, FINDING AND DISCUSSION

The preparation of comprehensive standards, guidelines, and regulatory frameworks for Electric Vehicle Charging Infrastructure (EVCS) in Nepal has been informed by extensive data analysis, technical assessments, and contextual evaluations aligned with the country's unique geographic, grid, and mobility characteristics.

The findings reveal that a systematic approach is essential to address multiple dimensions of EVCS development:

- **Standards and Guidelines:** Clear and harmonized standards for the design, installation, and operation of public charging infrastructures are crucial. This includes detailed specifications for both AC and DC charging systems, and differentiation between fast and slow chargers to meet diverse vehicle needs and user demand profiles.
- **Grid Connectivity Regulations:** Technical regulations addressing key grid parameters—such as power factor, load factor, harmonics, and voltage deviations—must be strictly defined and enforced to maintain grid stability. Safety standards must be integrated with existing electrical codes to safeguard both the distribution network and end-users.
- **Equipment Specifications and Interoperability:** Uniform specifications for equipment and products used in EVCS are required to ensure interoperability, user convenience, and maintainability. Responsibilities must be clearly allocated among relevant agencies to oversee compliance, certification, and periodic inspections.
- **Distribution Network Assessment:** The current capacity of the distribution network has been evaluated to determine its ability to meet the incremental load from EV charging. Grid Impact Studies (GIS) are particularly vital for heavy electric vehicle fleets, as high-capacity fast charging could induce significant localised load peaks that may affect power quality and stability.
- **Location Planning and Optimal Deployment:** Statistical analysis of the National Highways (SNH 2020/2021) has facilitated the identification of optimum numbers, locations, and density of charging points along major transport corridors. Factors such as traffic volumes, projected EV penetration, and road gradients—impacting vehicle mileage and charging demand—have been incorporated to ensure strategic placement.
- **Phased Rollout Strategy:** A phased implementation plan has been proposed:
  - **Phase I (1–3 years):** Establish basic coverage along key highways and urban centres.
  - **Phase II (3–6 years):** Expand network density and enhance grid readiness.
  - **Phase III (6+ years):** Integrate advanced technologies and support widespread adoption, including mega-scale fleet and heavy vehicle charging hubs.
- **Land Availability and Acquisition Modes:** The assessment highlights the need to secure suitable land parcels, prioritising the use of public land where feasible and supplementing with private land through leasing or other viable mechanisms to optimise cost and accessibility.

- **Safety and Regulatory Oversight:** All standards and guidelines must embed stringent safety protocols to mitigate risks to the grid and users, ensuring adherence to international best practices while addressing Nepal’s specific socio-technical context.

These results and analyses provide a solid evidence base to guide the structured development of EVCS across Nepal, balancing technical feasibility, economic viability, grid resilience, and environmental sustainability. The integrated approach will support the nation’s vision of a cleaner transport sector while enhancing energy security and fostering green economic growth.

## **4.1 GUIDELINES, STANDARDS, REGULATION AND SPECIFICATIONS FOR EV PUBLIC CHARGING INFRASTRUCTURE**

### **4.1.1 Guidelines of EV Public Charging infrastructure/Station**

As the number of electric vehicles is increasing, it is necessary to provide electric vehicle charging infrastructure in private and public places to develop electric vehicles as the future of transportation, to work on dependence on fossil fuels and to reduce the pollution caused by fossil fuel vehicles and to reduce the internal consumption of electricity. Since it is necessary to promote the electric charging station to increase, this procedure has been made by using the authority given by using the Terms of Reference, scope of work of WECS of “Preparation of Master Plan for Public Charging Infrastructure (PCI) on major National Highways for Electric Vehicles (EV)” for the purpose of making policy arrangements regarding its establishment and operation.

### **4.1.2 Classification of EVCS & their location**

4.1.2.1 Classification of EVCS: (1) Based on ownership and accessibility, charging stations are classified as follows:

- Private charging station
- Semi-public charging station
- Public charging station

The technical standards related to EVCS of the charging station should be as per current standards in Annex-I.

4.1.2.2 Establishment of Charging Station: Charging Stations can be installed and operated in the following locations.

- a. Can install and operate charging stations in the office premises of the Government of Nepal and government-owned entities, associations.
- b. Can install and operate charging stations in private or commercial buildings including office premises.
- c. Any manufacturers and EV Suppliers companies to install the charging station to facilitate the EV Users.
- d. Any individuals/ entity/firm/company to install charging station on both sides of road after the approval of authorizing body having ownership of that road.

- e. Any entity/firm/company to operate charging station on the commercial basis after registering in related agencies.

#### 4.1.2.3 To apply the application for the establishment of the EVPCI:

Entity/ firm/ company wishing to establish charging station shall submit the application to the relevant local office under the authority in the format attached in Annexure-V and the certified copy of the documents of stating the type of charging station. No fee shall be charged for such application.

- a. If the EVPCI is to be installed in private house or land for the private purposes, certified copy of the owner's registration certificate of the property, document related to EV and document containing proof of no electricity arrears if the electric line has already been installed shall be submitted.
- b. For the establishment of the public and semipublic EVPCI, the document of char killa, actual length and breadth of the land, location plan, land owner certificate, layout plan and specification of EV Chargers shall be submitted.
- c. Photograph and citizenship certificate in case of individual and firm registration certificate & tax clearance letter in case of firm.
- d. If there is no ownership of land (private land) shall submit the Lease contract agreement between land owner and owner of entity/firm/ company with land owner & citizenship certificate and if the public land shall submit the approval from Nepal Government related agencies.
- e. Any individuals/ entity/ firm/ company interested to install charging station on either sides of road shall submit the approval of authorizing body (Federal/Province/Local government) having ownership of that road.
- f. Any individuals/ entity/ firm/ company interested to install charging station on the public or commercial complexes parking areas shall submit the acceptance or authentic letter of Owner.
- g. Other specified remaining document shall be submitted as per Electricity Distribution Regulation -2078.

#### 4.1.2.4 Preliminary examination of the application: -

- a. The authority shall conduct preliminary examination of the documents received along with the application as per section 4.1.2.3.
- b. If any document is missing during the preliminary examination according to sub-section (a), the applicant must submit it as requested by the authority, otherwise the application may be rejected.
- c. In the course of the preliminary examination according to sub-section (a), if there are two or more applications for the same location at the same time, priority will be given to high-capacity fast charging stations.

#### 4.1.2.5 On-site technical inspection:

- a. Each Public Charging Station (PCS) should be operated only after approval from Nepal Electricity Authority, Energy Efficiency and Loss Reduction Department. For

this NEA shall appoint one or more technical staffs or engineers from NEA or also third party for the same.

- b. The team as per sub-section (a) shall submit a detailed inspection and report on whether the standards mentioned in 4.1.2.4 have been followed to the local office within seven days of visit as attached in Annexure V. It has to be submitted to the local office of the authority, along with the opinion/ recommendation. It should be sent to the designated office of the authority for approval.

4.1.2.6 Granting approval: -

According to sub-section (b) of section 4.1.2.5, if it is found appropriate after studying the report, approval shall be given within the seven days for the establishment of charging station.

### **4.1.3 Major operating policies of EVPCI**

4.1.3.1a Permission shall be given to

- a. Any individuals/ entity/ firm/ company to install the EV Public/ semi-public charging infrastructure/ charging station after submission of related document.
- b. Any individuals/ entity/firm/company to install the EV private charging infrastructure/ Charging station in private residences, offices, firm/ company/ institutions after submission of related document.
- c. Any government organization to install the charging station in the office compound.
- d. Any Private or commercial complexes including others to install the charging station in the office compound.
- e. Any manufacturers and EV Suppliers companies to install the charging station to facilitate the EV Users.
- f. Any individuals/ entity/firm/company to install charging station on both sides of road after the approval of authorizing body having ownership of that road.
- g. Any entity/firm/company to operate charging station on the commercial basis after registering in related agencies.

4.1.3.1b Owners will charge their Electric Vehicles at their residence/offices using their existing electricity connections

4.1.3.1c Any individual/ entity is free to set up Public and Semi-public Charging Infrastructure/ Stations provided that, such stations meet the technical, safety as well as performance standards, protocols and norms/ standards/ specifications laid down Ministry of Energy, Water Resource and Irrigation or/ and Nepal Electricity Authority from time to time

4.1.3.1d Priority will be given to individuals/ firms/ companies who want to operate Public and Semi Charging Infrastructure/ Stations in major urban areas of Nepal.

4.1.3.1e The Federal/ Province/ Local Government may also give priority to existing petrol pump and Public Bus Park for installation of EVPCI/ Station.

4.1.3.1f Re-usage, recycling or disposal of unusable EV batteries and other defunct electric devices in the charging station shall follow the provisions laid out in the Solid Waste Management Act-2068 and Solid Waste Management Rule -2070 Nepal.

4.1.3.2 Requirements of EV public and semi-public charging infrastructure/ stations

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Every Public and Semi-public Charging Infrastructure/ Station (PCI) will comply with the following: -

- a) 11/0.4kV or 33/0.4kV distribution transformer, 33kV or 11kV Distribution line, termination, metering and appropriate cabling & electrical works ensuring equipment's safety
  - All appropriate civil works related to it.
  - Adequate space for charging and entry/exit of vehicles.
  - Appropriate cabling & electrical works ensuring safety
  - Appropriate fire protection equipment and facilities.
  - Telephone/ mobile connection, supply of clean water, hygienic toilet facilities, sign boards with over-illuminating decoration. The compound shall stand higher than the road surface to facilitate water drainage.
  - The charging service provider may add other facilities such as hotel, restaurant, hair cutting, spa, gymnasium, and others etc. as deemed necessary.
  - Public Charging Infrastructure / Station shall have, any one or more chargers or any combination of chargers from the table given in ANNEX I & ANNEX II in one or more electric kiosk/boards.
  - Charging station for (two/three wheelers) e-vehicles shall be free to install any charger compliance of technical & safety standards as laid down by NEA or MOEWRI.
- b. Tie up with at least one advance remote/online booking system of each charger slot will have to be adopted with information (provided via online system) regarding the location, type of charger, number of charger and their availability etc.
- c. Any individuals/ entity/firm/company who takes NSPs service other than the NEA must share the data of their charging station with the NSPs system of the NEA.
- d. Public Charging Infrastructure/ Station for EV shall comply with the provision of NEA Electricity Distribution Regulations 2078 (Measures relating to safety and Electric supply)

#### 4.1.3.3 Public Charging Infrastructure (PCI) for long range EVs and/ or heavy duty EVs

4.1.3.3a. Fast Charging Stations (FCS) i.e. Public charging stations for long range EVs and/ or heavy duty EVs (like trucks, buses etc.) will have the following:

- i. At least two chargers of minimum 120 kW (200-1000 V or higher) each of different specification (CCS/CHAdEMO/GB/T Chargers for above capacity or BIS Standards for eBus Charging Station (Level-4: 250 to >500 kW, Automated Pantograph Charging Station) as provided under ANNEX II(f) with single connector / gun each.
- ii. Appropriate Liquid Cooled Cables for high speed charging facility as above 4.1.3.3a (i), for onboard charging of Fluid Cooled Batteries (currently available in some long range EVs), if required.
- iii. Charging service providers that charge batteries through swapping systems on off-board chargers shall manage appropriate Climate Control Equipment facilities.

- 4.1.3.3b. If adequate space is available at the Public Charging Station, in addition to the mandatory facilities mentioned above, it can also add standalone battery swapping facilities
- 4.1.3.3c. Captive Charging Infrastructure/ Station for 100% internal use for the company's own / Leased fleet for the own use will not be required to install chargers as per para 4.1.3.2 and to have Network Service Provider (NSPs) tie ups.
- 4.1.3.3d. If adequate space is available at the Public Charging Station, in addition to the mandatory facilities mention above, it can also add standalone battery swapping facilities.
- 4.1.3.3e. Public and Semi-Public Charging Infrastructure/ Station may also be installed by housing societies, shopping malls, offices, complexes, restaurants, hotels, etc. with a provision to allow charging of visitors' vehicles which are permitted to come in its premises
- 4.1.3.3f. The type test has been certified by an internationally recognized agency for Electric vehicle service equipment connected to public charging Infrastructure/stations. Such equipment should also be in use around the world for last three years.
- 4.1.3.3g. If charging service providers require additional charger to be installed on charging board, for that, prior approval should be obtained from the Nepal Electricity Authority or other related agencies.
- 4.1.3.3h Each Public Charging Station (PCS) should be operated only after approval from Nepal Electricity Authority, Energy Efficiency and Loss Reduction Department. For this NEA shall appoint one or more technical staffs or engineers from NEA or also third party for the same.

#### **4.1.4 Location of EV Public Charging Infrastructure/ Station**

In relation to public charging Infrastructure/ stations, the following minimum standards/criteria should be followed in terms of density/distance between two charging point which should be considered as below:

- 4.1.4.1. At least one charging station will be managed in the 3 km X 3 km grid at the urban area. Further, on the basis of the demand of private organizations, the area of the place (where the charger is kept) and other infrastructure chargers to be installed can be considered.
- 4.1.4.2. At least one fast charging station with charging infrastructure as mentioned above should be installed in each 25 to100 km for long distance electric vehicles (such as SUVs) or heavy-duty vehicles (such as bus/truck) etc.

#### **4.1.5 Provisions related Database, tariff and land**

##### **4.1.5.1. Database of Public Charging Stations**

Nepal Electricity Authority shall create, store, renew, and maintain a national online database of all Public Charging Stations. For this, NEA/MOEWRI shall inform about the appropriate protocols from time to time which shall be mandatorily fulfilled by Public Charging Infrastructure/ Stations.

##### **4.1.5.2 Tariff supply of electricity to EVPCI/Station**

The Service Provider operating Electric Vehicle Charging Infrastructure/ station should pay tariff rate as mentioned below: -

4.1.5.2a. The tariff for supply of electricity supplied to Public EV Charging Stations shall be as per Electricity Regulatory commission by Public transportation and the same tariff shall be applicable for Battery Charging Station (BCS).

4.1.5.2b. Tariff imposed on office/ firm/ company installing separate charging station for personal use shall be same as mentioned in sub clause 4.1.5.2a, but if such private stations allow the public use of such charging station, they cannot impose additional fee than the prescribed electricity tariff.

4.1.5.2c. The tariff applicable for domestic consumption shall be applicable for domestic charging of EV.

4.1.5.2d The separate metering arrangement shall be made for EVPCI/S so that consumption may be recorded and billed as per applicable tariff for the EVPCI/S.

4.1.5.2e Service Charge – Stipulated service charge for providing electric vehicle charging service. This charge shall include trading costs, storage costs, costs of machinery, charging point operators' profit, parking fees, and incidental costs. The combined price of the electricity tariff and service charge shall be considered the total expenses of the EV Charging process. In the case of charging infrastructure/ station, the authority may determine the maximum applicable service charge for EV Charging in accordance with the relevant recommendations of the technical committee of Nepal government.

##### **4.1.6 Provision regarding the promotional special arrangements regarding public charging infrastructure/ stations**

Nepal Electricity Authority will provide electricity service up to 33kV or 11kV distribution line with 200 kVA distribution transformer to the service providers who install charging stations.

In the case of charging stations with higher demand more than 200 kVA, the NEA will install 11 kV or 33 kV Distribution Line only. Remaining work will have to be done by the MOEWRI under the Rural Electrification and Distribution Line Rehabilitation Project carried out by the NEA as grant/ financial assistance from the MOEWRI or itself individual/ entity/ firm/ company own expenses/ investment.

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#### **4.1.7 Provision of land at promotional rates for Public Charging Infrastructure Stations**

- a. The entity/ firm/ company (charging service provider) can establish the EVPCI in own land. If there is no ownership of land (private land) shall submit the Lease contract agreement between land owner and owner of entity/ firm/ company with land owner & citizenship certificate. For the public land shall submit the approval from Nepal Government related agencies.
- b. The Revenue Sharing Model may also be adopted by the Public land-owning agency for providing the land to a private individuals/ entity/firm/company/ for installation of Public Charging Infrastructure/ Stations on bidding basis with floor price NRs 1.00/ kWh of consumed unit.

#### **4.1.8 Application for the establishment of the EVPCI:**

Entity/ firm/ company wishing to establish charging station shall submit the application to the relevant local office under the authority in the format attached in Annex-IV and the certified copy of the documents of stating the type of charging station. No fee shall be charged for such application.

- a. If the EVPCI is to be installed in private house or land for the private purposes, certified copy of the owner's registration certificate of the property, document related to EV and document containing proof of no electricity arrears if the electric line has already been installed shall be submitted.
- b. For the establishment of the public and semipublic EVPCI, the document of char killa, actual length and breadth of the land, location plan, land owner certificate, layout plan and specification of EV Chargers shall be submitted.
- c. Photograph and citizenship certificate in case of individual and firm registration certificate & tax clearance letter in case of firm.
- d. If there is no ownership of land (private land) shall submit the Lease contract agreement between land owner and owner of entity/firm/ company with land owner & citizenship certificate and if the public land shall submit the approval from Nepal Government related agencies.
- e. Any individuals/ entity/ firm/ company interested to install charging station on either sides of road shall submit the approval of authorizing body (Federal/Province/Local Government) having ownership of that road.
- f. Any individuals/ entity/ firm/ company interested to install charging station on the public or commercial complexes parking areas shall submit the acceptance or authentic letter of Owner.
- g. Other specified remaining document shall be submitted as per Electricity Distribution Regulation -2078.

#### **4.1.9 Operation and maintenance of charging station**

4.1.9.1 Operation of charging station: arrangements regarding the operation of charging station shall be as below:

- a. Each semi-public and public charging station shall be operated only after verifying the technical and safety standards of the connection, electrical and network infrastructures are suitable through monitoring and inspection by Nepal Electricity Authority
- b. For operation of semi-public and public charging station, there should be insurance covering the third party for compensation of infrastructure, fire and possible damages.

#### 4.1.9.2 Repair and maintenance of semi-public charging stations

Arrangements regarding Repair and maintenance of semi-public charging stations shall be as below:

- a. The electrical component connected to the charging stations should be regularly inspected, tested, repaired and maintained according to the guidelines of manuals of the charging stations.
- b. All the records of the design, construction, operation, inspection, testing and maintenance of the electrical equipment connected to the charging stations shall be kept safe, updated periodically and accessible to the concerned people.
- c. The charging station and its related equipment, safety related equipment shall be monitored and inspected by the local office of NEA at least once a year and certified as suitable/ operable.
- d. If it is not found suitable and operable during the monitoring and inspection according to clause©, a period of 15 days will be given to correct it. If no improvements are made within that period, NEA may order to close the charging station.

#### 4.1.9.3. Priority for Rollout of EV Public Charging Infrastructure

Considering these criteria, the phases for EVPCI rollout are;

- Projected EV flow and EVCS demand
- Important cities
- Important Highways/

Phase I (1-3 Years):

Phase II (3-6 Years):

Phase III (6-10 Years):

#### 4.1.10. Others

##### 4.1.10.1. Arrangements related to shutdown of electricity service of public charging stations:

According to the regulation, if a private EVPCI/ station established on public land after taking approval/ consent from the authorized body, leaves the public electric vehicle charging station in the middle or close without operating the service for a long time, the service of the charging station given to him will be stopped.

##### 4.1.10.2. Selection of Central Nodal Agency for Rollout EV Public Charging Infrastructure/ Station

The Ministry of Energy, Water resource and Irrigation shall nominate WECS or NEA Energy Efficiency and Loss Reduction Department as Central Nodal Agency (CNA) for rollout of the EV Public Charging Infrastructure/ Station. All relevant agencies shall provide necessary

support to Central Nodal Agency (CNA). The CNA shall finalize the cities and Highways to be finally taken up from the priority as given in para 4.6.2, in consultation with the respective Federal, Province & Local governments, NEA Provincial Office and respective stakeholders. The arrangements related to shutdown of electricity service of public charging stations are as follows: -

According to the regulation, if a private EVPCI/ station established on public land after taking approval/ consent from the authorized body, leaves the public electric vehicle charging station in the middle or close without operating the service for a long time, the service of the charging station given to him will be stopped.

The institutional provision and its recommendations for the EVCS establishment, operation and maintenance is shown in **Annex IV**.

## **4.2 SAFETY STANDARDS REQUIRED FOR THE GRID AND EV CHARGING INFRASTRUCTURE**

### **4.2A Safety Standards Required for The Grid to Be Insured Through Existing Regulations**

Safety standards for electric vehicle (EV) charging infrastructure are essential for ensuring reliability and compliance with regulations. These standards typically include requirements for electrical safety and fire safety

#### **Voltage variations (As per chapter 4.3.1 of Nepal Electricity Grid Code 2080)**

The designated system operator shall be ensured that the power supply voltage in the Grid on the major connection point during nominal operating condition shall not deviate by more than  $\pm 10\%$  its nominal value up to 132 kV and  $\pm 5\%$  its nominal value of 220kV and above.

#### **Frequency variations (As per chapter 4.3.2 of Nepal Electricity Grid Code 2080)**

The designated system operator shall be ensured that the fundamental frequency in the system is maintained between 48.75 Hz and 51.25 Hz i.e.  $\pm 2.5\%$  of 50 Hz which is nominal value of its nominal fundamental frequency.

#### **Maximum T/L Loss (As per chapter 4.4.2 of Nepal Electricity Grid Code 2080)**

The Grid owner insured that the T/L loss does not exceed 4.5% of the Received energy.

#### **Power Factor (As per chapter 5.3.4 of Nepal Electricity Grid Code 2080)**

The distributor shall maintain the level of power factor between 0.8 lagging and 0.95 leading and the Grid owner may disconnect the User for failing to maintain this standard

#### **Grounding Requirements (As per chapter 5.3.2 of Nepal Electricity Grid Code 2080)**

The grounding system at the connection point shall be designed to keep resin touch and step voltage in and around switchyard where operator are likely to be present within the acceptable safety limit specified by IEEE standard. The earth resistance at the connection point shall not exceed one ohms.

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**Distribution Transformer protection (As per chapter 5.7.5. 2 & 4 of Nepal Electricity Grid Code 2080)**

The Distribution Transformer low voltage side shall be connected in wye with neutral brought out for Earthing and O/C & E/F relays shall be provided all capacity of dist. Transformer with directional feature.

**Distribution line protection (As per ch.5.74.1 of Nepal Electricity Grid Code 2080)**

The minimum scheme for non-parallel lines shall consist of Non-Directional O/C & E/F Relays and the minimum scheme for parallel lines shall consist of directional O/C & E/F Relays.

*Source: Nepal Electricity Grid Code 2080*

**Safety Standards (As per chapter 4.5.1 of Nepal Electricity Grid Code 2080)**

The grid owner shall operate and maintain the grid in the safe manner in accordance with the provision in the Electricity Rule, 2050 (1993) and any amendments there of. Other provision not covered by the regulation shall be accordance with the Best Industries Practice

**AC Charger protection (As per IEC Standard/ manufacturer Standard)**

Over/ Under Voltage Protection, Overload Protection, Current Leakage Protection, Grounding Protection, Over Temp Protection, Lightning Surge Protection, Emergency Stop Button

**DC Charger protection (As per IEC Standard/ manufacturer Standard)**

Over/ Under Voltage Protection, Overload Protection, Current Leakage Protection, Grounding Protection Over Temp Protection, Lightning Surge Protection, Emergency Stop Button, LED Indicator, Card Swiping, Touch Screen, IP56

**Reactive Power**

The distribution licensee and bulk consumer shall provide adequate reactive compensation to compensate reactive power requirement in their system so that they do not depend upon the grid for reactive power support. The power factor for distribution system and bulk consumer shall be within  $\pm 0.95$ .

**Voltage and Current Harmonics**

The limits of voltage harmonics by the distribution licensee in its electricity system, the limits of injection of current harmonics by bulk consumers, point of harmonic measurement, i.e., point of common coupling, method of harmonic measurement and other related matters, shall be in accordance with the IEEE 519-2014 standards, as amended from time to time;

**Back-energization**

The consumer shall not energize transmission or distribution system by injecting supply from his generators or any other source either by automatic controls or manually unless specifically requested by the Transmission or Distribution Licensee.

*Source: Technical Standards for Connectivity to the Grid Regulations, Amendment 2019, India*

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#### **4.2B Safety Standards Required for Ev Public Charging Infrastructure/ Stations: -**

Safety standards for EV public charging infrastructure are critical to ensure the protection of users, property and the environment. These standards typically include requirements for user safety, electrical safety and fire safety.

##### **4.2B.1. General safety requirement for electric vehicle charging infrastructure/ stations.**

- a) All electric vehicle charging stations shall be designed, installed, tested, certified, inspected and connected in accordance with the provisions of this chapter.
- b) All electric vehicle charging stations shall be provided with protection against the overload of input supply and output supply fittings.
- c) All electric vehicle charging points shall be installed so that any socket-outlet of supply is at least 800 millimeters above the finished ground level.
- d) A cord extension set or second supply lead shall not be used in addition to the supply lead for the connection of the electric vehicle to the electric vehicle charging point and it shall be constructed so that it cannot be used as a cord extension set.
- e) An adaptor shall not be used to connect a vehicle connector to a vehicle inlet.
- f) The electric vehicle parking place shall be such that the connection on the vehicle when parked for charging shall be five meter within meter electric vehicle charging point.
- g) Portable socket-outlets are not permitted to be used for electric vehicle charging.
- h) Suitable lightning protection system shall be provided for the electric vehicles charging stations as per Indian Standards Code IS/ IEC 62305.
- i) The electric vehicle charging station shall be equipped with a protective device against the uncontrolled reverse power flow from vehicle.
- j) One second after having disconnected the electric vehicle from the supply (mains), the voltage between accessible conductive parts or any accessible conductive part and earth shall be less than or equal to 42.4 V peak (30 V rms) or 60 V D.C. and the stored energy available shall be less than 20 J (as per IEC 60950) and if the voltage is greater than 42.4 V peak (30 V rms) or 60 V D.C., or the energy is 20 J or more, a warning label shall be attached in an appropriate position on the charging stations.
- k) A vehicle connector used for Direct Current (D.C.) charging shall be locked on a vehicle inlet if the voltage is higher than 60 V D.C. and the vehicle connector shall not be unlocked (if the locking mechanism is engaged) when hazardous voltage is detected through charging process including after the end of charging and in case of charging system malfunction, a means for safe disconnection shall be provided.
- l) The Direct Current (D.C.) electric vehicle charging point shall disconnect supply of electricity to prevent overvoltage at the battery, if output voltage exceeds maximum voltage limit sent by the vehicle.
- m) The electric vehicle charging points shall not energize the charging cable when the vehicle connector is unlocked and the voltage at which the vehicle connector unlocks shall be lower than 60V.

##### **4.2B.2. Earth protection system for charging stations**

- (a) All residual current device for the protection of supplies for electric vehicle shall, -

- (i) Have a residual operating current of not greater than 30 mA;
  - (ii) Interrupt all live conductors, including the neutral; and
  - (iii) Have a performance at least equal to Type A and be in conformity with IS 732-2018.
- (b) All residual current devices used for the protection of supplies to electric vehicle shall be permanently marked to identify their function and the location of the charging station or socket outlet they protect.
- (c) Each electric vehicle charging points shall be supplied individually by a dedicated final sub-circuit protected by an overcurrent protective device complying with IEC 60947-2, IEC 60947-6-2 or the IEC 60269 series and the overcurrent protective device shall be part of a switchboard.
- (d) Co-ordination of various protective devices shall be required.
- (e) Where required for service reasons, discrimination (selectivity) shall be maintained between the residual current device protecting a connecting point and a residual current device installed upstream.
- (f) All electric vehicle charging stations shall be supplied from a sub-circuit protected by a voltage independent residual current device and also providing personal protection that is compatible with a charging supply for an electric vehicle.
- (g) All electric vehicle charging stations shall be provided with an earth continuity monitoring system that disconnects the supply in the event that the earthing connection to the vehicle becomes ineffective.
- (h) Earthing of all electric vehicle charging stations shall be as per IS 732.
- (i) The cable may be fitted with an earth-connected metal shielding and the cable insulation shall be wear resistant and maintain flexibility over the full temperature range.
- (j) A protective earth conductor shall be provided to establish an equipotential connection between the earth terminal of the supply and the conductive parts of the vehicle, which shall be of sufficient rating to satisfy the requirements of IEC 60364-5-54.

#### **4.2B.3. Requirement to prevent fire for electric vehicle charging stations**

- (a) Firefighting system for charging stations shall be provided in accordance with the provisions of these regulations.
- (b) Enclosure of charging stations shall be made of fire retardant material with self-extinguishing property and free from Halogen.
- (c) Fire detection, alarm and control system shall be provided as per relevant Indian Standards.
- (d) Power supply cables used in charging station or charging points shall conform to IEC 62893-1 and its relevant parts.

#### **4.2B.4. Safety Standards for Battery Charger**

When it comes to battery charger safety, there are several standards that need to be followed to ensure safe charging. These standards are designed to protect both the user and the battery itself. Here are some important safety standards for battery chargers:

**Ventilation:** Proper ventilation is crucial during battery charging to prevent the accumulation of potentially explosive gases. Charging batteries can produce hydrogen gas, which can be highly flammable. Ensure that the charging area is well-ventilated to minimize the risk of gas explosions.

**Avoid Sparks:** Sparks can ignite the hydrogen gas produced during battery charging, leading to a potential explosion. It is important to avoid any sparks or open flames near the charging area. This includes refraining from smoking or using any flammable materials in the vicinity.

**Terminal Safety:** When connecting the battery to the charger, ensure that the terminals are properly aligned and securely connected. Loose connections can lead to overheating, which can be dangerous. Always follow the manufacturer's instructions for proper terminal connections.

**Proper Use and Discharge:** It is essential to use the battery charger as intended and avoid overcharging or undercharging the battery. Overcharging can lead to overheating and damage the battery, while undercharging can result in reduced battery performance. Follow the recommended charging times and discharge the battery properly before recharging.

#### **4.2B.5. Other Relevant Safety Requirements**

##### **Testing of charging stations**

- (a) All apparatus of charging stations shall have the insulation resistance value as stipulated in the relevant IEC 61851-1.
- (b) The owner of the charging station shall ensure that the tests as specified in the manufacturer's instructions for the residual current device and the charging station have been carried out.

##### **Inspection and periodic assessment of charging stations**

- (a) Every charging station shall be tested and inspected by the owner or the Electrical Inspector or Chartered Electrical Safety Engineer before energization of charging stations.
- (b) The owner of the charging station shall ensure that test and inspection of charging station is being carried out every year in the initial period of first three years after the energization of charging station and in every four years thereafter.
- (c) The owner of the charging station shall establish and implement a safety assessment program for regular periodic assessment of the electrical safety of charging station.

##### **Maintenance of records**

- (a) The owner of the charging station shall keep records in regard to design, construction and labelling to be compatible with a supply of standard voltage at a nominal frequency of 50 Hertz of the charging station.
- (b) The owner of the charging station shall keep records of the relevant test certificate as indicated in these regulations and as per IEC 61851.
- (c) The owner of the charging station shall keep records of the results of every inspection, testing and periodic assessment and details of any issues observed during the assessment and any actions required to be taken in relation to those issues.
- (d) The owner of the charging station shall retain a copy of all records, as specified in sub regulation (a), (b) and (c) of above, either in hard copy or in electronic form, for at least seven years and shall provide a copy of the records to the officials during the inspection.

### **International Standard for charging stations**

- (a) The safety provisions of all Alternating Current charging stations shall be in accordance with IEC 61851-1, IEC 61851-21 and IEC 61851-22.
- (b) The safety provisions of all Direct Current charging stations shall be in accordance with IEC 61851-1, IEC 61851-21, IEC 61851-23 and IEC 61851-24.
- (c) Where the connection point is installed outdoors, or in a damp location, the equipment shall have a degree of protection of at least IPX4 (Ingress Protection Code) in accordance with IEC 60529

### **Safety Issues with Electric Buses**

Another major concern with the usage of electric buses is the safety of these buses, and thereby the safety of the passengers. This primarily arises due to the use of batteries which can be affected by:

Mechanical abuse -

Mechanical abuse typically refers to the intentional or unintentional mistreatment or misuse of mechanical devices, machinery, or equipment, leading to damage, malfunction, or reduced lifespan. This could include actions such as overloading, improper maintenance, ignoring operating guidelines, or using the equipment in ways it was not designed for. For example, forcefully applying pressure or stress beyond the equipment's capacity, neglecting lubrication schedules, or ignoring safety protocols could all constitute mechanical abuse.

Mechanical abuse is hard to prevent and happens mostly due to shocks and vibrations in transportation of batteries and their daily operations.

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### 4.3 REGULATION REGARDING CONNECTIVITY WITH THE GRID

#### 4.3.1 Regulation Regarding Connectivity with the Grid Power Factor, Load Factor, Harmonics, Voltage Deviations, etc.

When preparing regulations regarding the connectivity of electric vehicle (EV) charging infrastructure with the grid, several factors must be considered to ensure efficient and reliable operation such as Power Factor, Load Factor, Harmonics, Voltage Deviations, Grid Code Compliance.

- Voltage variations (As per chapter 4.3.1 of Nepal Electricity Grid Code 2080)  
The designated system operator shall be ensured that the power supply voltage in the Grid on the major connection point during nominal operating condition shall not deviate by more than  $\pm 10\%$  its nominal value up to 132 kV and  $\pm 5\%$  its nominal value of 220kV and above.
- Frequency variations (As per chapter 4.3.2 of Nepal Electricity Grid Code 2080)  
The designated system operator shall be ensured that the fundamental frequency in the system is maintained between 48.75 Hz and 51.25 Hz i.e.  $\pm 2.5\%$  of 50 Hz which is nominal value of its nominal fundamental frequency.
- Maximum T/L Loss (As per chapter 4.4.2 of Nepal Electricity Grid Code 2080)  
The Grid owner insured that the T/L loss does not exceed 4.5% of the Received energy.
- Power Factor (As per chapter 5.3.4. of Nepal Electricity Grid Code 2080)  
The distributor shall maintain the level of power factor between 0.8 lagging and 0.95 leading and the Grid owner may disconnect the User for failing to maintain this standard
- Grounding Requirements (As per chapter 5.3.2. of Nepal Electricity Grid Code 2080)  
The grounding system at the connection point shall be designed to keep resin touch and step voltage in and around switchyard where operator is likely to be present within the acceptable safety limit specified by IEE standard. The earth resistance at the connection point shall not exceed one ohms.
- Distribution Transformer protection (As per chapter 5.7.5. 2 & 4 of Nepal Electricity Grid Code 2080)  
The Distribution Transformer low voltage side shall be connected in wye with neutral brought out for Earthing and O/C & E/F relays shall be provided all capacity of dist. Transformer with directional feature.
- Distribution line protection :( As per ch.5.7.4.1 of Nepal Electricity Grid Code 2080)  
The minimum scheme for non-parallel lines shall consist of Non-Directional O/C & E/F Relays and the minimum scheme for parallel lines shall consist of directional O/C & E/F Relays.
- Safety Standards (As per chapter 4.5.1 of Nepal Electricity Grid Code 2080)  
The grid owner shall operate and maintain the grid in the safe manner in accordance with the provision in the Electricity Rule, 2050 (1993) and any amendments thereof.

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Other provision not covered by the regulation shall be accordance with the Best Industries Practice

- DC Charger protection (As per IEC Standard/ manufacturer Standard)  
Over/ Under Voltage Protection, Overload Protection, Current Leakage Protection, Grounding Protection Over Temp Protection, Lightening Surge Protection, Emergency Stop Button, LED Indicator, Card Swiping, Touch Screen, IP56.
- Reactive Power  
The distribution licensee and bulk consumer shall provide adequate reactive compensation to compensate reactive power requirement in their system so that they do not depend upon the grid for reactive power support. The power factor for distribution system and bulk consumer shall be within  $\pm 0.95$ .
- Voltage and Current Harmonics  
The limits of voltage harmonics by the distribution licensee in its electricity system, the limits of injection of current harmonics by bulk consumers, point of harmonic measurement, i.e., point of common coupling, method of harmonic measurement and other related matters, shall be in accordance with the IEEE 519-2014 standards, as amended from time to time;
- Back-energization  
The consumer shall not energize transmission or distribution system by injecting supply from the generators or any other source either by automatic controls or manually unless specifically requested by the Transmission or Distribution Licensee.

*Source: Nepal Electricity Grid Code 2080 and Technical Standards for Connectivity to the Grid Regulations, Amendment 2019, India*

### **4.3.2 Field Assessment of the Stability and Adequacy of the Existing Power Source Which Connect the Charging Station to The Grid**

Nepal's transition to electric mobility relies heavily on the stability and adequacy of its existing power grid, particularly in supporting charging stations along highways and urban centers. Nepal's unique energy landscape dominated by hydropower and characterized by seasonal variations assessing the grid's capacity, reliability, and infrastructure readiness is crucial for sustainable EV integration.

#### **1. Existing Power Source and Grid Stability**

Nepal's electricity supply is primarily hydropower-based, contributing over 90% of the total generation capacity. Key observations regarding the grid stability include:

- Installed Capacity: As of 2024, Nepal's total installed electricity generation capacity is approximately 2,500 MW, with several upcoming projects aiming to increase capacity beyond 5,000 MW by 2030 and 28500 MW up to 2035.  
(Source: Nepal's Energy Development Roadmap, approved in January 2025)

- **Surplus Power in Monsoon, Shortages in Winter:** Nepal faces a power surplus during the monsoon season but reduced generation in the dry season (winter) due to lower river flows, leading to potential seasonal shortages for EV charging infrastructure.
- **Voltage Fluctuations & Load Shedding:** While load shedding has significantly decreased, voltage instability and power fluctuations in remote areas could affect the efficiency of fast-charging stations.
- **Grid Expansion & Reliability:** The Nepal Electricity Authority (NEA) is working on grid modernization, but transmission and distribution bottlenecks remain a challenge in rural and highway areas.

The Major Highlight of this Fiscal year 2023/24 area presented below:

1	Annual System Peak Demand	2467 MW	3/31/2081
2	Annual System Energy Demand	14624 GWh	
3	Annual National Energy Demand	2212 GWh	2/16/2081
4	Annual National Energy Demand	12681 GWh	
5	Annual Load Factor	65.56%	
6	Total Exported Energy (Annual)	1946 GWh	
7	The Maximum Exported Energy in a Single Day	17.92 GWh	3/28/2081
8	Per Capita Electricity Consumption	400 KWh	
*Provisional figures based on LDC data			

(Source: NEA Annual Report:2023/24)

## 2. Adequacy for EV Charging Infrastructure

With Nepal's EV sector growing, the integration of charging stations depends on the grid's ability to handle increased demand.

- **Power Demand for EV Charging:**
  - A typical DC fast-charging station (50 kW–150 kW) requires significant power draw, potentially affecting local grids.
  - An EV charging hub with multiple chargers could demand over 1 MW which can be challenging for weaker grid areas.
- **Urban Areas vs. Highways:**
  - Kathmandu, Pokhara, and major cities have relatively stable power supplies, making them suitable for large EV charging hubs.
  - Highway regions, particularly rural and hilly areas, face grid reliability issues due to outdated transmission lines and low-capacity transformers.
- **Future Power Supply & EV Growth:**
  - Nepal's electricity demand is projected to rise by over 7–10% annually, and widespread EV adoption could add 434 GWh additional load by 2030 and 1314 GWh up to 2035 as per Energy demand forecast.
  - Without grid upgrades and dedicated high-capacity transmission lines, rapid EV expansion could strain the existing system.

The Detail Assessment of Distribution Network Stability and Adequacy existing power sources connect EV Charging Infrastructure to the Grid has been shown Table below: -

**Table 23: Province Wise Electrification Status**

S. N.	Province	Households Nos	Electrification Status (%)	33/11 Kv Substation				33kV Line	11kV Line	LT Line	Transformer
				Existing		Under Construction		Existing Km	Existing Km	Existing Km	Existing kVA
				Nos.	Capacity (MVA)	Nos.	Capacity (MVA)				
1	Koshi	11,91,556	94.78	35	531.70	22	154	1,119.70	9,673.77	26,357.95	7,846
2	Madhesh	11,56,715	100.00	26	418.70	14	206.6	773.04	6,851.03	23,271.59	6,577
3	Bagmati	15,70,927	99.21	31	266.40	14	107	790.86	10,805.78	33,699.89	11,277
4	Gandaki	6,62,480	99.02	24	212.00	7	31	769.80	5,483.00	14,053.47	3,916
5	Lumbini	11,41,902	97.94	36	218.60	20	212	2,611.63	7,835.21	25,320.01	7,368
6	Karnali	3,66,255	66.49	11	54.50	19	57	468.00	3,074.43	7,238.14	1,865
7	Sudhurpaschim	5,77,102	82.02	24	202.00	14	47	703.69	4,008.99	15,328.98	3,336
<b>Total</b>		<b>66,66,937</b>	<b>91.35</b>	<b>187</b>	<b>1,903.90</b>	<b>110</b>	<b>814.60</b>	<b>7,236.72</b>	<b>47,732.21</b>	<b>1,45,270.03</b>	<b>42,185</b>

(Source: Nepal Electrification Statistics:2023)

### **3. Recommendations for Power Source Improvement**

To ensure adequate and stable power supply for EV charging, Nepal should focus on:

- Upgrading transmission infrastructure to support high-power EV chargers along highways.
- Deploying battery energy storage systems (BESS) to stabilize voltage fluctuations.
- Encouraging solar-integrated EV charging stations to reduce grid dependency, especially in remote areas.
- Implementing smart-grid solutions to balance demand and optimize energy distribution.

#### **Conclusion**

While Nepal's hydropower-based grid has the potential to support EV charging, challenges such as seasonal power fluctuations, weak transmission lines, and uneven grid access must be addressed. Strategic investments in grid modernization, renewable energy integration, and smart infrastructure will be essential to ensure a stable and reliable power supply for Nepal's growing EV ecosystem.

#### **4.3.3 Assessment of The Capacity of the Distribution Network to Supply the Load Of The EVCS**

The Assessment of Distribution Network Capacity for EV Charging Stations (EVCS) evaluates the grid's ability to handle additional EV charging loads without overloading transformers, feeders, or substations. It includes load demand analysis, grid reinforcement, renewable integration, and smart charging strategies to ensure stable and efficient power supply. The Distribution Infrastructure Network of Nepal is shown in below figure.

## Distribution Infrastructures of Nepal

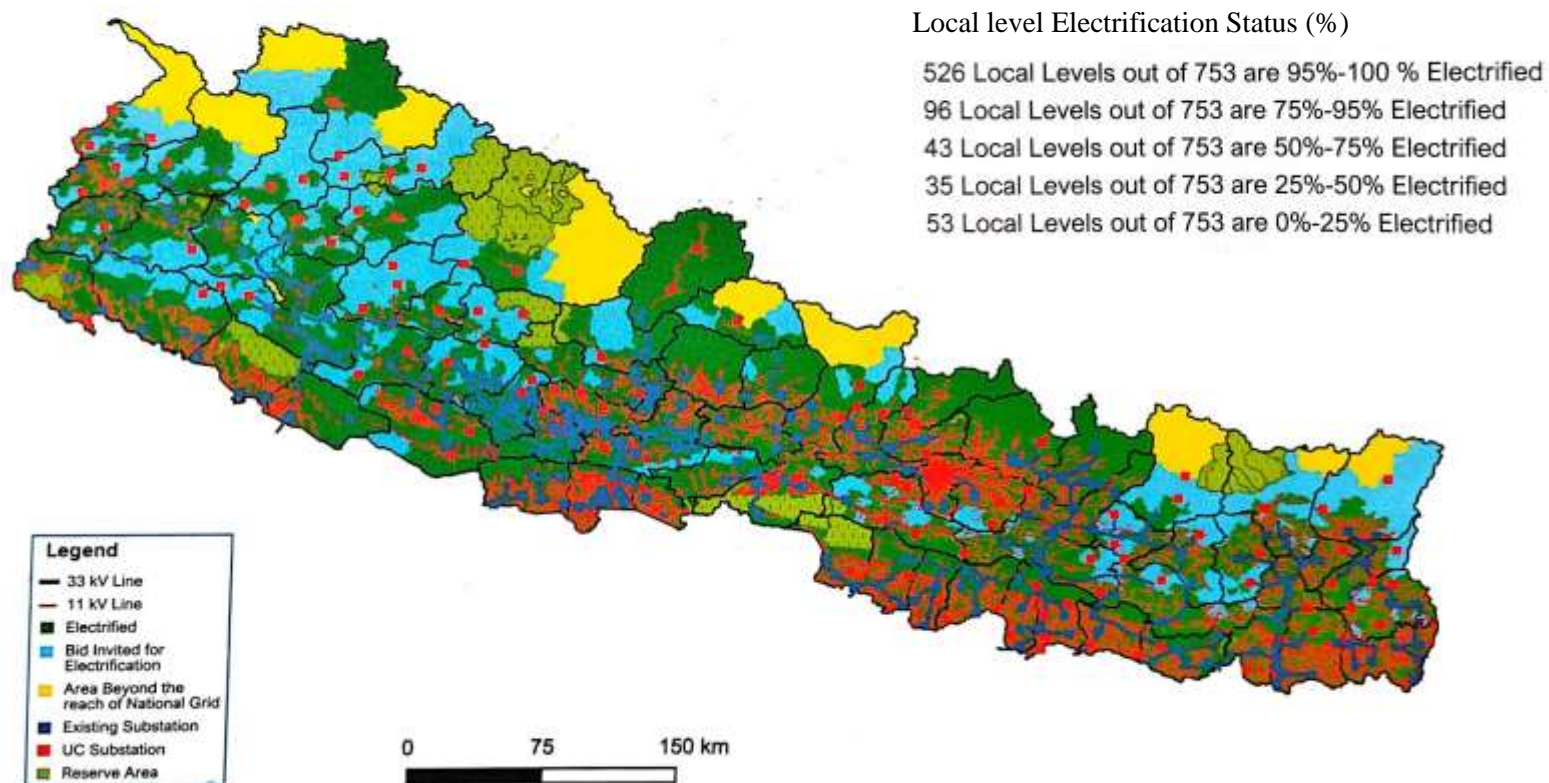


Figure 16: Distribution Infrastructures of Nepal

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The evaluation typically involves the following key aspects:

### Load Demand Analysis

- ⦿ Increasing EV Adoption → Higher electricity demand on Nepal's grid.
- ⦿ Calculate total power demand using:

$$P_{total} = N_c \times P_c \times U$$

where:

$N_c$  = Number of chargers

$P_c$  = Power rating of each charger (kW)

$U$  = Usage factor (charging hours per day)

Peak demand challenge → Charging load may stress the grid during peak hours.

### Grid Capacity & Transformer on Nepal's grid.

- ⦿ Limited transmission & distribution capacity in Nepal's hilly terrain.
- ⦿ Need for grid reinforcement in urban areas (Kathmandu, Pokhara) and highways.
- ⦿ Voltage drops & power quality issues due to weak infrastructure.

### Renewable Energy & Storage Integration

- ⦿ Hydropower potential can support EV charging stations.
- ⦿ Solar-powered charging stations for rural & highway locations.
- ⦿ Battery storage systems can help balance supply-demand gaps.

### Smart Grid & Demand Response

- ⦿ Load management strategies to prevent grid overload.
- ⦿ Implement Time-of-Use (TOU) pricing → Encourage off-peak charging.
- ⦿ Develop smart charging stations with dynamic load balancing.

#### ❖ Infrastructure Investment & Policies

- ⦿ Upgrade transformers, feeders, and substations along major highways (Prithvi, Tribhuvan).
- ⦿ Government incentives for fast-charging infrastructure.
- ⦿ Public-Private Partnerships (PPP) for EV charging network expansion.

**Recommendation:** Nepal needs grid upgrades, renewable integration, and smart charging solutions to support EVCS growth. Investment in hydropower-based charging infrastructure and policy support will ensure sustainable EV adoption.

The Detail Assessment of Distribution Network Capacity for EV Charging Stations (EVCS) of the field visit for EVCS location has been attached in the Annex IX.

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#### **4.3.4 Grid Impact Study of Heavy Vehicle Integration**

The integration of heavy electric vehicles (HEVs), such as electric car, micro bus, buses and trucks, poses significant challenges to the power grid due to their need for extremely fast charging, often at multiple-megawatt levels. When several HEVs charge simultaneously, the grid experiences sudden and concentrated load spikes, which can result in voltage fluctuations, reduced power factor, and high load factor stress. Additionally, the use of high-power electronic converters introduces substantial harmonic distortion in both current and voltage waveforms, potentially violating grid quality standards. This background highlights the need for a comprehensive Grid Impact Study (GIS) to assess and mitigate the technical impacts of HEV fast-charging integration on the electrical network.

Case Study: Grid Impact Analysis of Heavy Electric Vehicle (HEV) Fast Charging at Sajha Yatayat, Pulchowk

Consumer Name: M/S.Sajha Yatayat Charging

Consumer Number:207-104021980

Consumer ID:104021980

Approved Load(kVA):500

Meter No.:45230000699

Sajha Yatayat, a leading public transport cooperative in Kathmandu Valley, has significantly advanced its electric bus operations by introducing 40 electric buses and establishing Nepal's largest EV charging station at Pulchowk, Lalitpur. The charging facility, inaugurated in April 2024, features 24 charging points with a total capacity of approximately 1.1 MW, enabling simultaneous fast charging of multiple buses to meet operational demands.

For this grid impact study, a focus is placed on a subset of the charging infrastructure comprising five DC fast chargers (DCFC), each rated at 90 kW with a single charging gun, resulting in a total load of 450-500 kW. This setup serves as a representative case to analyze how large, concentrated fast charging loads affect the local power system.

The study involves detailed monitoring and analysis of multi-parameter electrical profiles, including:

- Voltage stability and fluctuations
- Power factor variations
- Load factor changes
- Harmonic currents and voltage distortions

These parameters are critical to understanding the impact of simultaneous fast charging on grid stability, power quality, and overall system performance.

Given the high power demand and the potential for simultaneous charging of multiple heavy electric vehicles, the study aims to identify:

- Potential voltage drops or instability issues
- Transformer and feeder loading and thermal stress

- Power quality degradation due to harmonics
- Opportunities for implementing smart charging or demand management strategies

This case study is particularly relevant as Sajha Yatayat previously faced operational limitations due to insufficient charging infrastructure, which restricted the number of buses in operation to 22 out of 40. The new charging station at Pulchowk addresses these limitations, enabling full fleet deployment while presenting new challenges for grid management.

Insights gained from this analysis will support utilities and planners in optimizing grid operations, planning necessary upgrades, and ensuring reliable, efficient integration of heavy electric vehicle fast charging infrastructure in urban public transport systems.

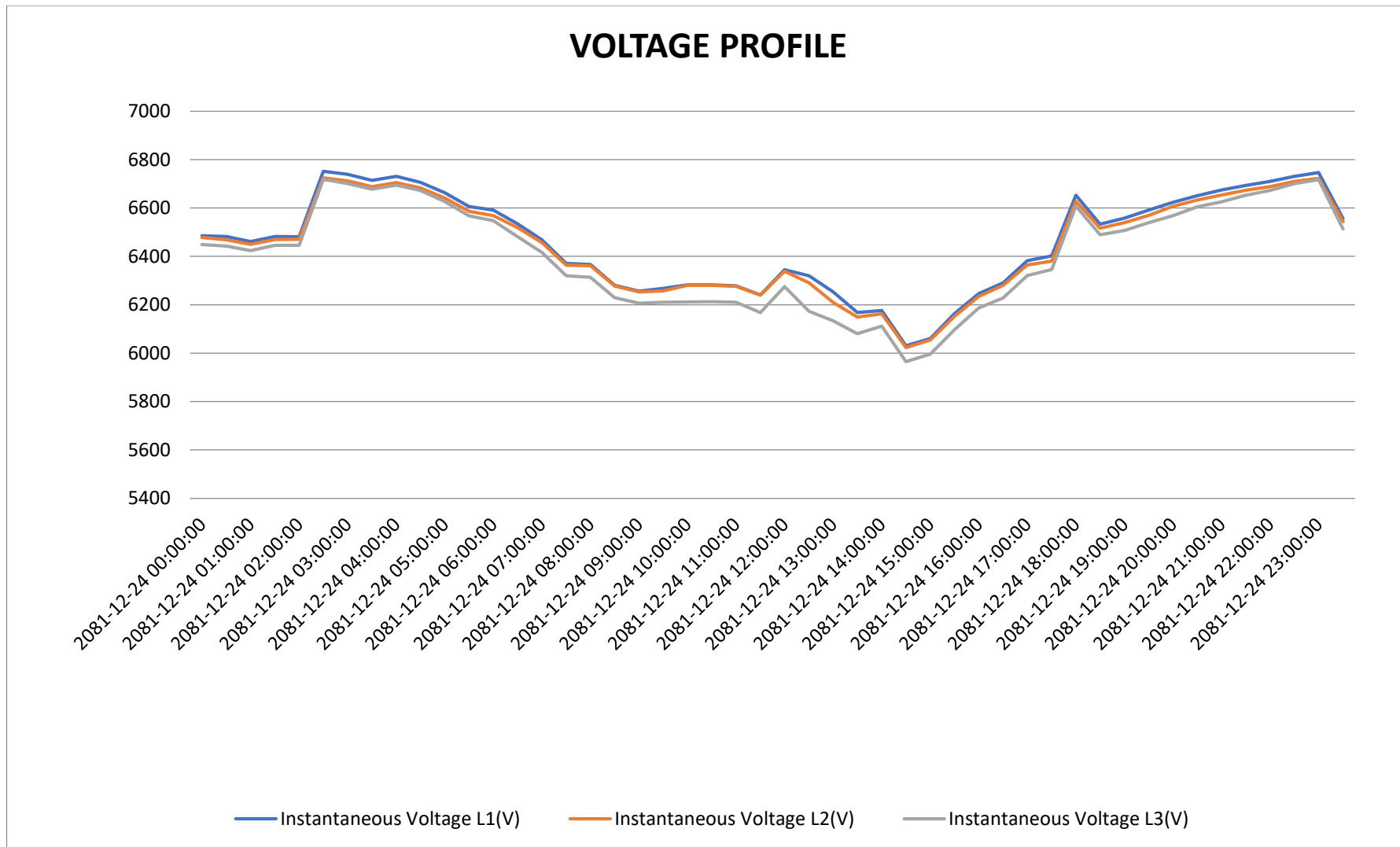
## Case Study of Data and their Analysis

### 1.Voltage Profile

**Table 24:Voltage Profile of EVCS**

Data Time	Instantaneous Voltage L1(V)	Instantaneous Voltage L2(V)	Instantaneous Voltage L3(V)
2081-12-24 00:00:00	6485	6478	6449
2081-12-24 00:30:00	6482	6469	6443
2081-12-24 01:00:00	6461	6450	6424
2081-12-24 01:30:00	6482	6470	6446
2081-12-24 02:00:00	6481	6471	6446
2081-12-24 02:30:00	6752	6725	6718
2081-12-24 03:00:00	6739	6712	6701
2081-12-24 03:30:00	6714	6688	6678
2081-12-24 04:00:00	6731	6705	6694
2081-12-24 04:30:00	6706	6683	6673
2081-12-24 05:00:00	6663	6641	6627
2081-12-24 05:30:00	6606	6586	6568
2081-12-24 06:00:00	6591	6569	6548
2081-12-24 06:30:00	6534	6519	6481
2081-12-24 07:00:00	6469	6457	6417
2081-12-24 07:30:00	6371	6364	6320
2081-12-24 08:00:00	6367	6361	6314
2081-12-24 08:30:00	6280	6277	6229
2081-12-24 09:00:00	6256	6253	6206
2081-12-24 09:30:00	6268	6257	6211
2081-12-24 10:00:00	6282	6280	6212
2081-12-24 10:30:00	6282	6280	6213
2081-12-24 11:00:00	6278	6276	6211
2081-12-24 11:30:00	6241	6240	6168
2081-12-24 12:00:00	6345	6339	6275
2081-12-24 12:30:00	6320	6291	6173

<b>Data Time</b>	<b>Instantaneous Voltage L1(V)</b>	<b>Instantaneous Voltage L2(V)</b>	<b>Instantaneous Voltage L3(V)</b>
2081-12-24 13:00:00	6253	6210	6134
2081-12-24 13:30:00	6168	6149	6081
2081-12-24 14:00:00	6176	6163	6112
2081-12-24 14:30:00	6031	6023	5965
2081-12-24 15:00:00	6061	6055	5996
2081-12-24 15:30:00	6164	6152	6097
2081-12-24 16:00:00	6246	6235	6187
2081-12-24 16:30:00	6291	6280	6228
2081-12-24 17:00:00	6382	6365	6321
2081-12-24 17:30:00	6402	6380	6346
2081-12-24 18:00:00	6653	6628	6608
2081-12-24 18:30:00	6533	6517	6489
2081-12-24 19:00:00	6558	6539	6507
2081-12-24 19:30:00	6591	6570	6539
2081-12-24 20:00:00	6624	6607	6569
2081-12-24 20:30:00	6651	6633	6605
2081-12-24 21:00:00	6675	6654	6626
2081-12-24 21:30:00	6693	6674	6653
2081-12-24 22:00:00	6710	6688	6673
2081-12-24 22:30:00	6731	6710	6701
2081-12-24 23:00:00	6746	6723	6717
2081-12-24 23:30:00	6556	6544	6513



**Figure 17: Voltage Profile of EVCS**

The graph shows the phase angle difference between voltage (U) and current (I) for three phases (L1, L2, L3) over a 24-hour period on 2081-12-24.

The y-axis represents the phase angle in degrees, and the x-axis represents the time of day.

#### a) Phase Angle Behavior

**L1 (Blue Line):** The phase angle is relatively stable, staying close to zero degrees throughout the day, with a slight increase between 6:00 and 8:00.

**L2 (Red Line):** The phase angle has some fluctuations throughout the day, especially between 8:00 and 17:00.

**L3 (Green Line):** The phase angle increases significantly between 6:00 and 8:00 and decreases between 17:00 and 18:00.

#### b) Potential Grid Impacts

**High-Phase Angle Differences:** Large phase angle differences between voltage and current can indicate reactive power flow. This can lead to increased losses in the grid, voltage instability, and reduced power transfer capability.

**Fluctuations:** The fluctuations observed in L2 may indicate changing load conditions or intermittent generation sources connected to that phase. This can cause voltage fluctuations and potential issues with power quality.

**Phase Imbalance:** Differences in the phase angle profiles between the three phases (L1, L2, and L3) suggest a phase imbalance in the system. This can lead to increased neutral current, transformer overheating, and reduced efficiency.

#### c) Mitigation measures

- Upgrading conductors and distribution infrastructure to reduce losses and improve capacity.
- Reconfiguring feeders or distribution systems to optimize power flow and voltage profiles.
- Installing and optimally placing capacitor banks to improve power factor and voltage regulation.
- Incorporating distributed generation and renewable energy resources in a controlled manner to balance load and generation.
- Employing smart charger functionalities, on-site photovoltaic (PV) generation, and energy storage systems (ES) to mitigate voltage impacts from high-demand loads such as heavy-duty EV charging stations.
- Conducting load flow and fault level assessments to identify thermal overloads and voltage violations, followed by network reinforcement or protection coordination improvements as needed.

- Implementing adaptive protection schemes and dynamic reactive power compensation to maintain voltage stability and system reliability.
- Periodically assessing the cumulative impact of distributed generation to plan upgrades and maintain grid stability over time.
- Utilizing scenario-based simulations and predictive analytics to proactively design and deploy mitigation strategies aligned with evolving load and generation patterns.

The above mitigation measures collectively enhanced grid stability, reduce losses, and ensure reliable integration of new generation and loads into the distribution and transmission systems.

## 2. Load Profile

**Table 25: Load Profile of EVCS**

Date/Time	Instantaneous Current L1(A)	Instantaneous Current L2(A)	Instantaneous Current L3(A)
2081-12-24 00:00:00	0.05	0.06	0.05
2081-12-24 00:30:00	0.05	0.05	0.05
2081-12-24 01:00:00	0.05	0.05	0.05
2081-12-24 01:30:00	0.05	0.05	0.05
2081-12-24 02:00:00	0.05	0.05	0.05
2081-12-24 02:30:00	0.06	0.07	0.06
2081-12-24 03:00:00	0.06	0.07	0.06
2081-12-24 03:30:00	0.06	0.07	0.06
2081-12-24 04:00:00	0.06	0.07	0.06
2081-12-24 04:30:00	0.06	0.07	0.06
2081-12-24 05:00:00	0.06	0.06	0.06
2081-12-24 05:30:00	0.06	0.06	0.05
2081-12-24 06:00:00	17.75	17.59	17.47
2081-12-24 06:30:00	10.5	10.41	10.34
2081-12-24 07:00:00	4.81	4.74	4.73
2081-12-24 07:30:00	0.07	0.07	0.08
2081-12-24 08:00:00	0	0.05	0
2081-12-24 08:30:00	0	0.05	0
2081-12-24 09:00:00	0	0.05	0
2081-12-24 09:30:00	0	0.05	0
2081-12-24 10:00:00	0	0.05	0
2081-12-24 10:30:00	0	0.05	0
2081-12-24 11:00:00	0	0.05	0
2081-12-24 11:30:00	0	0	0
2081-12-24 12:00:00	0	0.05	0
2081-12-24 12:30:00	0	0	0
2081-12-24 13:00:00	0	0	0
2081-12-24 13:30:00	0	0	0
2081-12-24 14:00:00	0	0	0

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<b>Date/Time</b>	<b>Instantaneous Current L1(A)</b>	<b>Instantaneous Current L2(A)</b>	<b>Instantaneous Current L3(A)</b>
2081-12-24 14:30:00	0	0	0
2081-12-24 15:00:00	0	0	0
2081-12-24 15:30:00	0	0	0
2081-12-24 16:00:00	0	0.05	0
2081-12-24 16:30:00	0	0.05	0
2081-12-24 17:00:00	0	0.05	0
2081-12-24 17:30:00	0	0.05	0
2081-12-24 18:00:00	3.71	3.65	3.65
2081-12-24 18:30:00	3.78	3.72	3.72
2081-12-24 19:00:00	14.09	13.96	13.89
2081-12-24 19:30:00	17.5	17.27	17.24
2081-12-24 20:00:00	6.23	6.16	6.18
2081-12-24 20:30:00	17	16.8	16.78
2081-12-24 21:00:00	12.56	12.43	12.43
2081-12-24 21:30:00	14.11	13.88	13.94
2081-12-24 22:00:00	11.02	10.85	10.89
2081-12-24 22:30:00	0.98	0.97	0.98
2081-12-24 23:00:00	0.06	0.07	0.06
2081-12-24 23:30:00	0.05	0.06	0.05

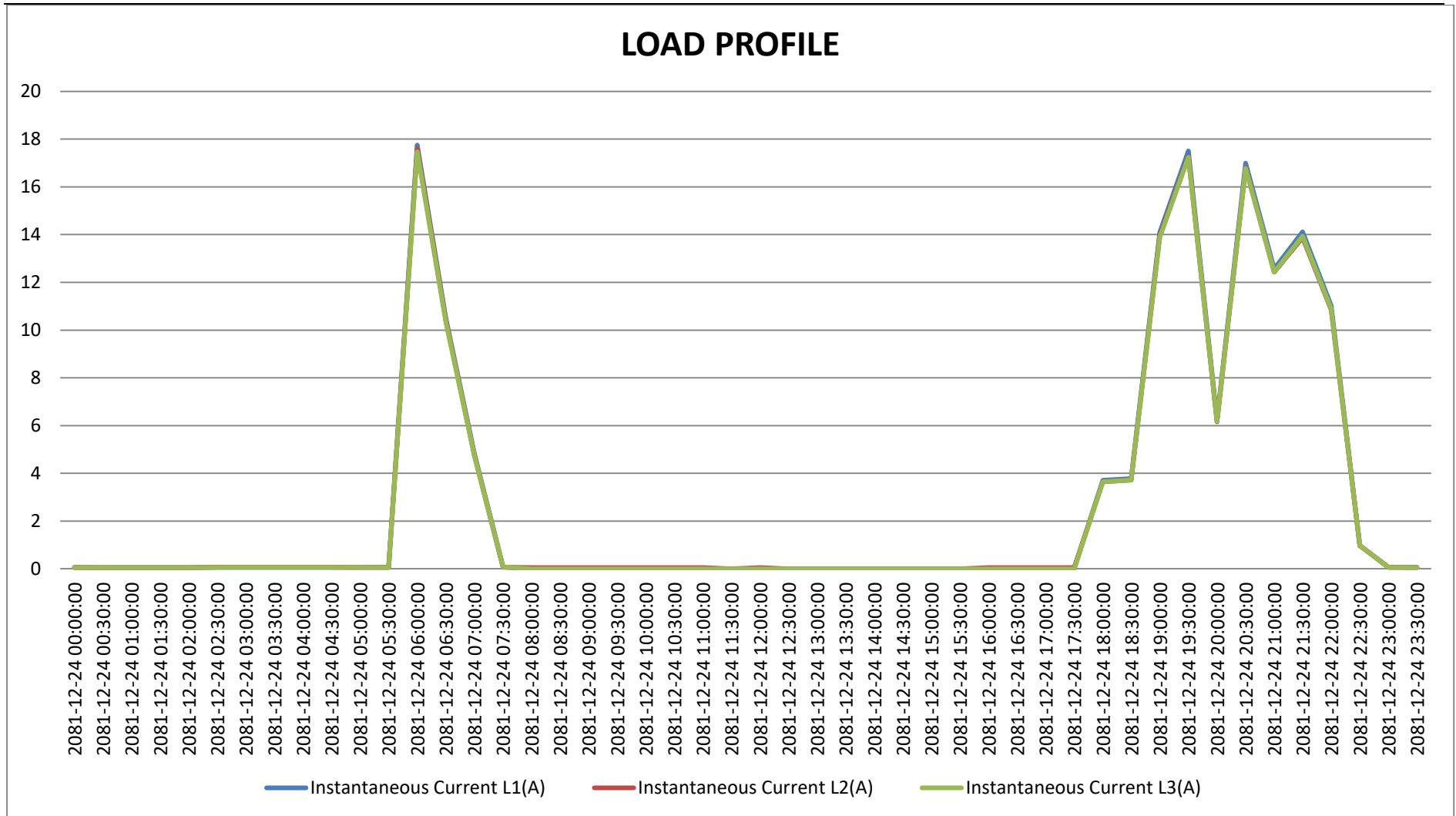


Figure 18: Load Profile of EVCS

The graph shows the instantaneous current for three phases (L1, L2, L3) over a 24-hour period on 2081-12-24. The current is measured in Amperes (A).

L1 and L2 have zero current flow for the entire day.

L3 is the only phase with current.

#### a) Load Profile Behavior (L3)

- **Peak at 7:00:** There's a sharp, significant current peak at 7:00.
- **Evening Peak (19:00 - 22:00):** A broader, less intense peak occurs between 19:00 and 22:00, with some fluctuations.
- **Other Times:** The current is at or near zero for the rest of the day.

#### b) Potential Grid Impacts

- **Sudden Load Changes:** The sharp peak at 7:00 represents a sudden surge in demand. This can cause voltage dips and frequency fluctuations if the grid isn't prepared to handle the rapid change in load.
- **Capacity Issues:** The evening peak, while less intense, could still strain the grid, especially if it coincides with peak demand from other sources. The grid needs sufficient capacity to supply this load without causing voltage drops or overloading equipment.
- **Phase Imbalance:** Since only L3 shows a load, there is a significant phase imbalance. This can lead to increased neutral current, transformer overheating, and reduced efficiency.

#### c) Mitigation Measures

- **Load Shaping:** Implement strategies like time-of-use pricing or demand response programs to encourage customers to shift their electricity usage away from peak hours.
- **Grid Reinforcement:** Upgrade distribution infrastructure (e.g., transformers, conductors) to handle peak loads and reduce voltage drops.
- **Phase Balancing:** Implement measures to balance the load across all three phases. This could involve redistributing loads or using phase balancing transformers.
- **Energy Storage:** Deploy energy storage systems (e.g., batteries) to store energy during low demand periods and release it during peak periods. This can help reduce the strain on the grid during peak hours.
- **Smart Grid Technologies:** Use advanced metering infrastructure (AMI) and other smart grid technologies to monitor grid conditions in real-time and respond to fluctuations in demand.
- **Distributed Generation:** Encourage the use of distributed generation resources (e.g., solar panels, small wind turbines) to supplement grid supply, especially during peak hours.
- **Load Forecasting:** Improve load forecasting techniques to predict peak demand more accurately and plan accordingly.

- **Demand Response:** Implement demand response programs that allow the utility to remotely control or curtail certain loads during peak demand periods.
- **Power Factor Correction:** Install power factor correction equipment to improve the power factor and reduce losses.
- **Regular Monitoring and Maintenance:** Conduct regular monitoring and maintenance of grid infrastructure to identify and address potential problems before they lead to outages or other issues.

### 3.Power Factor

**Table 26:Power Factor of EVCS**

Data Time	Instantaneous Power Factor L1(null)	Instantaneous Power Factor L2(null)	Instantaneous Power Factor L3(null)
2081-12-24 00:00:00	0.679	0.528	0.529
2081-12-24 00:30:00	0.679	0.535	0.537
2081-12-24 01:00:00	0.693	0.554	0.553
2081-12-24 01:30:00	0.675	0.541	0.537
2081-12-24 02:00:00	0.688	0.547	0.537
2081-12-24 02:30:00	0.554	0.464	0.421
2081-12-24 03:00:00	0.577	0.481	0.434
2081-12-24 03:30:00	0.595	0.485	0.443
2081-12-24 04:00:00	0.583	0.485	0.444
2081-12-24 04:30:00	0.585	0.5	0.459
2081-12-24 05:00:00	0.599	0.509	0.457
2081-12-24 05:30:00	0.627	0.531	0.493
2081-12-24 06:00:00	0.998	0.998	0.998
2081-12-24 06:30:00	0.997	0.997	0.996
2081-12-24 07:00:00	0.996	0.996	0.996
2081-12-24 07:30:00	0.629	0.455	0.559
2081-12-24 08:00:00	1	0.586	1
2081-12-24 08:30:00	1	0.608	1
2081-12-24 09:00:00	1	0.602	1
2081-12-24 09:30:00	1	0.617	1
2081-12-24 10:00:00	1	0.571	1
2081-12-24 10:30:00	1	0.594	1
2081-12-24 11:00:00	1	0.585	1
2081-12-24 11:30:00	1	1	1
2081-12-24 12:00:00	1	0.589	1
2081-12-24 12:30:00	1	1	1
2081-12-24 13:00:00	1	1	1
2081-12-24 13:30:00	1	1	1
2081-12-24 14:00:00	1	1	1
2081-12-24 14:30:00	1	1	1
2081-12-24 15:00:00	1	1	1

<b>Data Time</b>	<b>Instantaneous Power Factor L1(null)</b>	<b>Instantaneous Power Factor L2(null)</b>	<b>Instantaneous Power Factor L3(null)</b>
2081-12-24 15:30:00	1	1	1
2081-12-24 16:00:00	1	0.611	1
2081-12-24 16:30:00	1	0.599	1
2081-12-24 17:00:00	1	0.578	1
2081-12-24 17:30:00	1	0.551	1
2081-12-24 18:00:00	0.994	0.994	0.993
2081-12-24 18:30:00	0.997	0.997	0.996
2081-12-24 19:00:00	0.997	0.997	0.996
2081-12-24 19:30:00	0.998	0.998	0.997
2081-12-24 20:00:00	0.939	0.938	0.937
2081-12-24 20:30:00	0.998	0.998	0.997
2081-12-24 21:00:00	0.998	0.997	0.997
2081-12-24 21:30:00	0.997	0.996	0.996
2081-12-24 22:00:00	0.997	0.997	0.997
2081-12-24 22:30:00	0.997	0.996	0.996
2081-12-24 23:00:00	0.555	0.468	0.416
2081-12-24 23:30:00	0.654	0.516	0.5

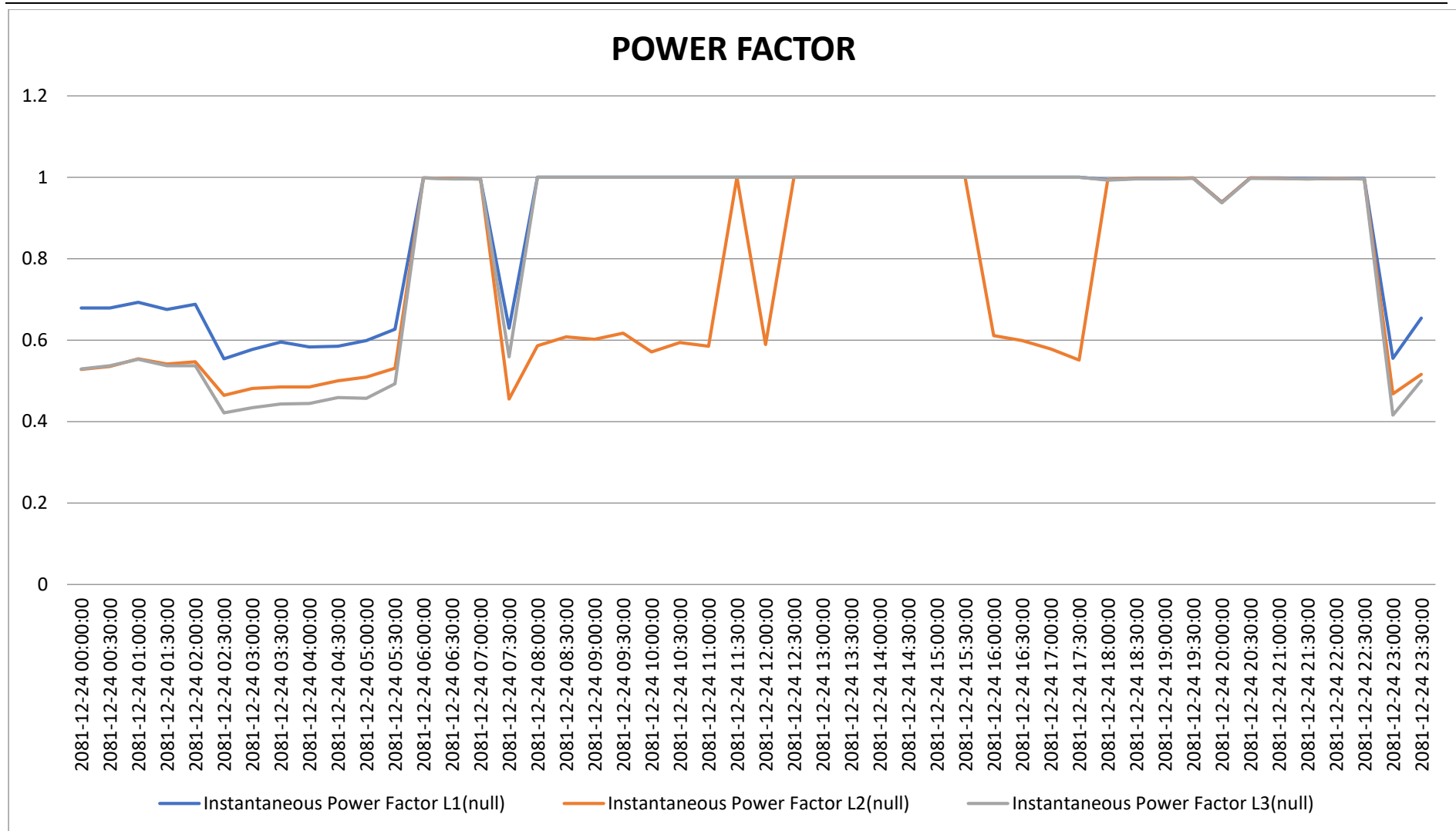


Figure 19 :Power Factor of EVCS

**Overall Power Factor:** The power factor varies across the three lines (L1, L2, and L3) throughout the day.

**a) Impact on Grid:**

**Low Power Factor (below 0.8):** From 00:00:00 to 06:00:00, the power factor for all three lines is below 0.8. This indicates a higher reactive power demand. A consistently low power factor can lead to:

- Increased current flow, causing higher losses in transmission and distribution lines.
- Voltage drops, potentially affecting the performance of other connected equipment.
- Reduced grid capacity, as a portion of the current is used for reactive power.
- Potential penalties from the utility for poor power factor.

**Power Factor Correction:** From 06:00:00 to 23:00:00, the power factor is corrected. A power factor close to 1 indicates that the system is utilizing electrical power efficiently. The benefits of maintaining a high power factor include:

- Reduced energy losses in the distribution system.
- Improved voltage regulation.
- Increased system capacity.
- Lower electricity bills.

**b) Common Mitigation Techniques that can improve the Power Factor:**

**Install Power Factor Correction Capacitors:**

- **How it works:** Capacitors provide reactive power to offset the inductive reactive power drawn by inductive loads, like motors and transformers.
- **Implementation:** Install capacitor banks at strategic locations within the electrical system, such as near large motors or at the main distribution board.
- **Benefits:** Reduces the amount of reactive power drawn from the grid, lowering current flow and losses in the distribution system.

**Use Synchronous Condensers:**

- **How it works:** Synchronous condensers are synchronous motors that run without a mechanical load and can supply or absorb reactive power.
- **Implementation:** Install synchronous condensers at substations or large industrial facilities to provide dynamic power factor correction.
- **Benefits:** Provides a stable and adjustable source of reactive power, improving voltage regulation and system stability.

**Apply Active Power Factor Correction (APFC):**

- **How it works:** APFC uses electronic components to actively control the waveform of the current drawn by a load, making it more sinusoidal and in phase with the voltage.
- **Implementation:** Integrate APFC circuits into individual devices or equipment with non-linear loads, such as power supplies and electronic ballasts.

- **Benefits:** Provides precise and dynamic power factor correction, reducing harmonic distortion and improving overall power quality.

#### Reduce Idling or Lightly Loaded Motors:

- **How it works:** Motors operating at less than their rated load tends to have a lower power factor.
- **Implementation:** Replace oversized motors with appropriately sized ones or implement motor control strategies to reduce idling time.
- **Benefits:** Improves the power factor of the motor load, reducing reactive power consumption.

#### Optimize Transformer Operation:

- **How it works:** Transformers also consume reactive power, especially when lightly loaded.
- **Implementation:** Operate transformers near their rated capacity or replace them with energy-efficient models.
- **Benefits:** Reduces reactive power losses in the transformer, improving the overall power factor of the system.

#### 4. Phase Angle Profile

**Table 27: Phase Angle Profile of EVCS**

Data Time	Angle of U(L1) - I(L1)(°)	Angle of U(L2) - I(L2)(°)	Angle of U(L3) - I(L3)(°)
2081-12-24 00:00:00	47.6	62	61.1
2081-12-24 00:30:00	48.6	61.7	60.2
2081-12-24 01:00:00	47.1	60.3	60
2081-12-24 01:30:00	47.5	61	61.2
2081-12-24 02:00:00	47.6	61.3	61.4
2081-12-24 02:30:00	55.4	65.2	68
2081-12-24 03:00:00	54.1	64.5	67.4
2081-12-24 03:30:00	53.5	64.8	66.4
2081-12-24 04:00:00	53.9	64.4	67
2081-12-24 04:30:00	53.3	64.1	65.9
2081-12-24 05:00:00	52.9	63.4	65.6
2081-12-24 05:30:00	51.4	62.6	63.8
2081-12-24 06:00:00	356.8	357.4	357.1
2081-12-24 06:30:00	355.5	356.1	355.7
2081-12-24 07:00:00	355.1	355.6	355
2081-12-24 07:30:00	303.4	296.1	299.7
2081-12-24 08:00:00	0	59.6	0
2081-12-24 08:30:00	0	57.7	0
2081-12-24 09:00:00	0	57.3	0

<b>Data Time</b>	<b>Angle of U(L1) - I(L1)(°)</b>	<b>Angle of U(L2) - I(L2)(°)</b>	<b>Angle of U(L3) - I(L3)(°)</b>
2081-12-24 09:30:00	0	57	0
2081-12-24 10:00:00	0	58.8	0
2081-12-24 10:30:00	0	57.6	0
2081-12-24 11:00:00	0	58.8	0
2081-12-24 11:30:00	0	0	0
2081-12-24 12:00:00	0	59.3	0
2081-12-24 12:30:00	0	0	0
2081-12-24 13:00:00	0	0	0
2081-12-24 13:30:00	0	0	0
2081-12-24 14:00:00	0	0	0
2081-12-24 14:30:00	0	0	0
2081-12-24 15:00:00	0	0	0
2081-12-24 15:30:00	0	0	0
2081-12-24 16:00:00	0	57.3	0
2081-12-24 16:30:00	0	58.7	0
2081-12-24 17:00:00	0	60.3	0
2081-12-24 17:30:00	0	60.2	0
2081-12-24 18:00:00	354.1	354.5	353.8
2081-12-24 18:30:00	355.7	356.1	355.4
2081-12-24 19:00:00	355.9	356.5	356.1
2081-12-24 19:30:00	356.6	357	356.5
2081-12-24 20:00:00	353.8	353.8	353.5
2081-12-24 20:30:00	356.8	357.2	356.7
2081-12-24 21:00:00	356.3	356.5	356.2
2081-12-24 21:30:00	355.7	356	355.4
2081-12-24 22:00:00	356	356.3	355.8
2081-12-24 22:30:00	356.1	355.2	355.5
2081-12-24 23:00:00	54.8	65.3	68.2
2081-12-24 23:30:00	49.8	62.9	63.1

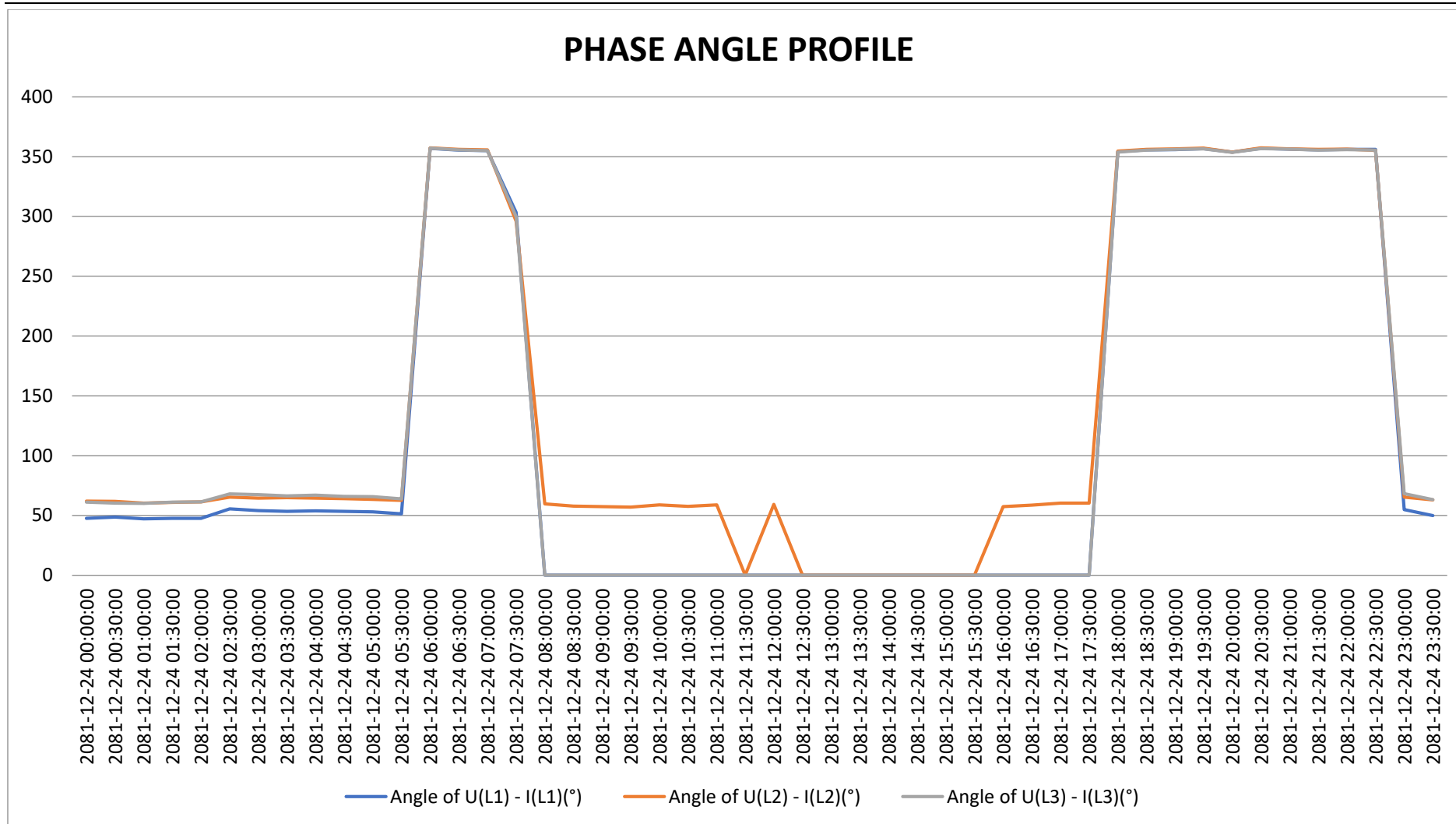


Figure 20 : Phase Angle Profile of EVCS

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**Based on the Phase Angle Profile graph,**

**Phase Angle Differences:** The phase angle between voltage and current varies across the three lines (L1, L2, and L3) throughout the day.

**a) Impact on Grid:**

**Phase imbalance:** The phase angle for L3 is significantly higher between 06:00 and 18:00, which creates imbalance. Large phase angle differences between phases can lead to:

- Increased neutral current, potentially overloading the neutral conductor.
- Voltage imbalances, affecting the performance of three-phase equipment and sensitive loads.
- Increased losses in transformers and distribution lines.
- Protection system mal operation.

**Harmonic Distortion:** Distorted current waveforms, indicated by phase angle fluctuations, can lead to:

- Overheating of transformers and conductors.
- Resonance with grid impedance, amplifying harmonic currents and voltages.
- Interference with communication and control systems.
- Reduced equipment lifespan.

**Stability Issues:** Large and rapid phase angle changes can indicate potential instability in the grid. Monitoring phase angles is crucial for:

- Detecting oscillations and preventing cascading failures.
- Implementing control actions to maintain synchronism between different parts of the grid.
- Ensuring reliable operation of power system equipment.

**b) Mitigation Techniques**

- Phase Balancing Techniques:
  - Load Balancing:

**How it works:** Distribute loads evenly across the three phases to minimize phase imbalances.

**Implementation:** Redistribute single-phase loads, such as lighting and small appliances, to balance the current draw on each phase.

**Benefits:** Reduces neutral current, voltage imbalances, and losses in the distribution system.

- Automatic Voltage Regulators (AVR):

**How it works:** AVRs regulate the voltage on each phase independently to compensate for voltage imbalances.

**Implementation:** Install AVRs at substations or critical load points to maintain a balanced voltage supply.

**Benefits:** Improves voltage regulation and reduces the impact of phase imbalances on sensitive equipment.

- Harmonic Filtering:
  - Passive Filters:

**How it works:** Passive filters consist of inductors, capacitors, and resistors that are tuned to filter out specific harmonic frequencies.

**Implementation:** Install passive filters at the source of harmonic distortion, such as variable frequency drives (VFDs) or power electronic converters.

**Benefits:** Reduces harmonic distortion and prevents resonance with grid impedance.

- Active Filters:

**How it works:** Active filters use electronic components to actively inject harmonic currents that cancel out the harmonic currents generated by non-linear loads.

**Implementation:** Install active filters at the point of common coupling (PCC) to mitigate harmonic distortion in the entire system.

**Benefits:** Provides dynamic and precise harmonic filtering, improving power quality and system stability.

- Advanced Grid Management:
- Smart Inverters:

**How it works:** Smart inverters can actively control the reactive power output and voltage on each phase, improving grid stability and power quality.

**Implementation:** Integrate smart inverters into distributed generation systems, such as solar and wind power plants, to support grid voltage and frequency.

**Benefits:** Enhances grid stability, reduces voltage imbalances, and improves the integration of renewable energy sources.

- Dynamic VAR Compensation (DVC):

**How it works:** DVC systems provide fast and accurate reactive power compensation to stabilize voltage and prevent voltage collapse.

**Implementation:** Install DVC systems at strategic locations in the grid to improve voltage stability and increase power transfer capacity.

**Benefits:** Enhances grid stability, reduces voltage fluctuations, and improves the reliability of the power supply.

## 5. THD of Voltage Profile

**Table 28: THD of Voltage Profile of EVCS**

Data Time	Current Average value of THD of Voltage L1(%)	Current Average value of THD of Voltage L2(%)	Current Average value of THD of Voltage L3(%)
2081-12-24 00:00:00	3.6	3.8	3.6
2081-12-24 00:30:00	3.6	3.7	3.6
2081-12-24 01:00:00	3.6	3.6	3.5
2081-12-24 01:30:00	3.5	3.6	3.5
2081-12-24 02:00:00	3.5	3.6	3.5
2081-12-24 02:30:00	3.5	3.6	3.5
2081-12-24 03:00:00	3.6	3.7	3.6
2081-12-24 03:30:00	3.6	3.7	3.5
2081-12-24 04:00:00	3.6	3.7	3.5
2081-12-24 04:30:00	3.6	3.7	3.5

<b>Data Time</b>	<b>Current Average value of THD of Voltage L1(%)</b>	<b>Current Average value of THD of Voltage L2(%)</b>	<b>Current Average value of THD of Voltage L3(%)</b>
2081-12-24 05:00:00	3.6	3.7	3.5
2081-12-24 05:30:00	3.4	3.5	3.3
2081-12-24 06:00:00	3.2	3.3	3.2
2081-12-24 06:30:00	3	3.1	3
2081-12-24 07:00:00	2.9	3	2.9
2081-12-24 07:30:00	2.6	2.6	2.5
2081-12-24 08:00:00	2.3	2.3	2.3
2081-12-24 08:30:00	2.4	2.4	2.4
2081-12-24 09:00:00	2.3	2.3	2.3
2081-12-24 09:30:00	2.2	2.3	2.3
2081-12-24 10:00:00	2.3	2.4	2.3
2081-12-24 10:30:00	2.3	2.5	2.4
2081-12-24 11:00:00	2.4	2.6	2.5
2081-12-24 11:30:00	2.4	2.7	2.6
2081-12-24 12:00:00	2.4	2.7	2.6
2081-12-24 12:30:00	0	3.7	3.8
2081-12-24 13:00:00	4.8	4.9	5
2081-12-24 13:30:00	2.7	2.8	2.8
2081-12-24 14:00:00	2.7	2.8	2.8
2081-12-24 14:30:00	2.7	2.8	2.7
2081-12-24 15:00:00	2.6	2.7	2.7
2081-12-24 15:30:00	2.8	2.8	2.8
2081-12-24 16:00:00	2.7	2.8	2.8
2081-12-24 16:30:00	2.8	2.8	2.8
2081-12-24 17:00:00	2.8	2.9	2.8
2081-12-24 17:30:00	2.8	2.9	2.8
2081-12-24 18:00:00	2.9	3.1	3
2081-12-24 18:30:00	3.3	3.6	3.4
2081-12-24 19:00:00	3	3.3	3.1
2081-12-24 19:30:00	3.3	3.5	3.3
2081-12-24 20:00:00	3.4	3.5	3.3
2081-12-24 20:30:00	3.6	3.8	3.5
2081-12-24 21:00:00	3.6	3.8	3.5
2081-12-24 21:30:00	3.5	3.8	3.5
2081-12-24 22:00:00	3.6	3.9	3.5
2081-12-24 22:30:00	3.4	3.6	3.3
2081-12-24 23:00:00	3.3	3.6	3.3
2081-12-24 23:30:00	3.6	3.8	3.5

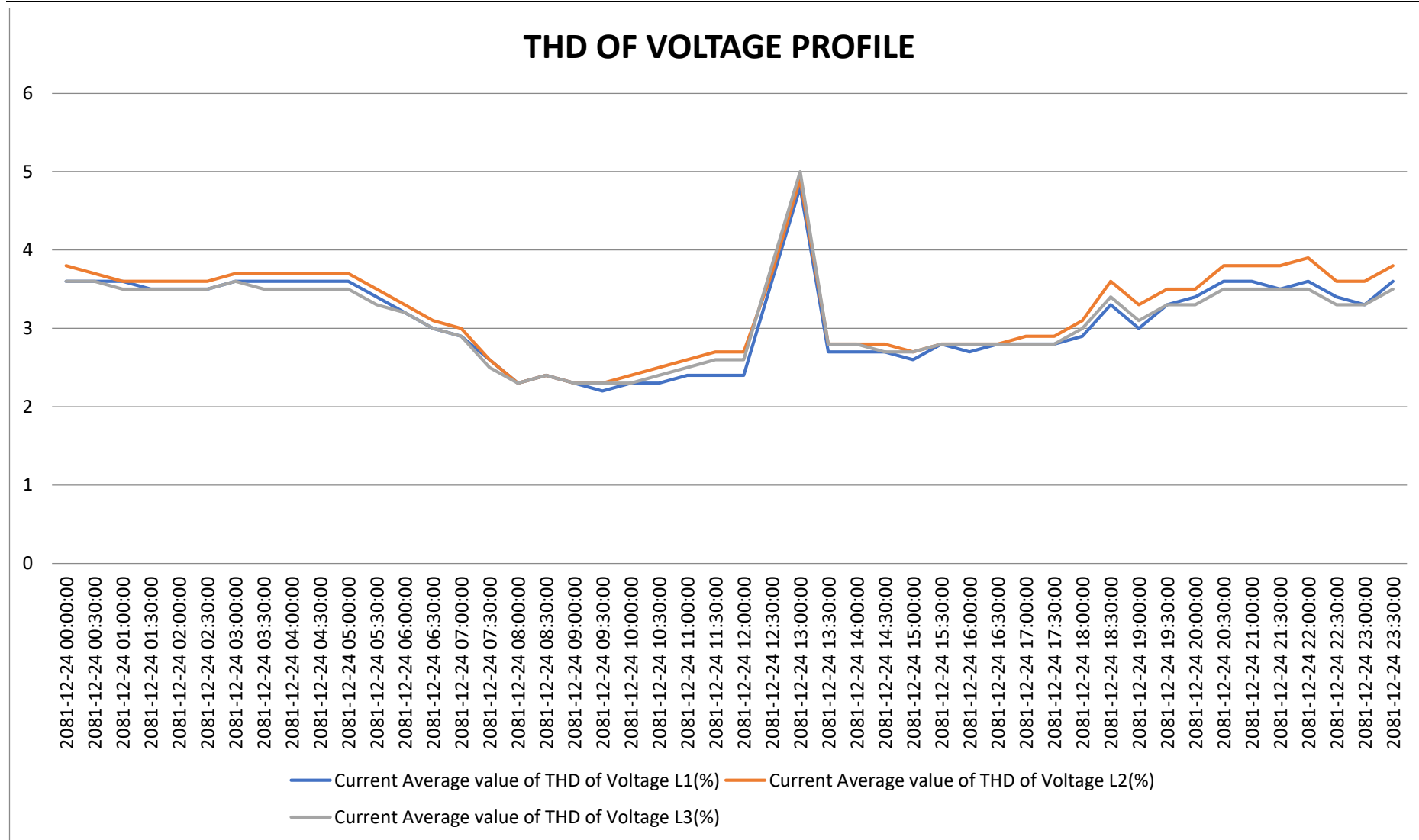


Figure 21 : THD of Voltage Profile of EVCS

The graph displays the Total Harmonic Distortion (THD) of the voltage profile for three phases (L1, L2, and L3) over a 24-hour period.

The THD values for all three phases generally range from 2% to 4%, which is within acceptable limits for most grid applications.

All three phases exhibit similar trends, indicating a balanced system.

#### **Specific Points of Interest:**

- **00:00 to 07:00:** The THD levels are relatively stable and within the range of 3.5% to 4%.
- **07:00 to 13:00:** There is a gradual decrease in THD from 3.5% to around 2.5%.
- **13:00:** A sharp spike in THD is observed, reaching a peak of approximately 5% on the L3 phase. This could be due to a sudden load change or the switching of non-linear loads.
- **14:00 to 18:00:** The THD levels stabilize again, fluctuating between 2.5% and 3%.
- **18:00 to 23:00:** The THD values gradually increase, returning to the initial levels of 3.5% to 4%.

#### **a) Grid Impact:**

- **Harmonic Resonance:** High THD can cause harmonic resonance, which can lead to voltage and current amplification, potentially damaging equipment.
- **Equipment Overheating:** Harmonics can cause transformers, motors, and cables to overheat, reducing their lifespan.
- **Metering Errors:** Harmonics can interfere with the accuracy of energy meters, leading to billing errors.
- **Protection System Malfunction:** Harmonics can cause protective devices like fuses and circuit breakers to operate incorrectly.

#### **Recommendations:**

- Investigate the cause of the THD spike at 13:00.
- Implement harmonic mitigation techniques such as filters or reactors if THD levels consistently exceed acceptable limits.
- Regularly monitor THD levels to ensure grid stability and equipment protection.

#### **b) To mitigate the grid impact of harmonics, consider these strategies:**

- **Identify Harmonic Sources:** Conduct a harmonic study to pinpoint the major sources of harmonic distortion within the system. This could involve analyzing individual loads or equipment.
- **Apply Harmonic Filters:** Install tuned or broadband harmonic filters at the identified harmonic sources or at strategic locations within the network.
- **Use Active Harmonic Conditioners:** Implement active harmonic conditioners that inject anti-phase currents to cancel out existing harmonics in real-time.

- **Isolate Sensitive Equipment:** Use isolation transformers or line reactors to prevent harmonics from propagating to sensitive equipment.
- **Improve Power Factor:** Implement power factor correction techniques, as poor power factor can exacerbate harmonic distortion issues.
- **Upgrade Equipment:** Replace or upgrade equipment known to produce significant harmonics with newer, more efficient models that incorporate harmonic mitigation features.
- **Optimize System Design:** Review and optimize the system design to minimize impedance and resonance conditions that can amplify harmonics.
- **Implement Standards and Guidelines:** Adhere to IEEE 519 standards and other relevant guidelines for harmonic control in electrical power systems.
- **Monitor and Maintain:** Continuously monitor harmonic levels and equipment performance to identify and address any new or recurring harmonic issues.
- **Adjust Load Management:** Adjust load management to avoid simultaneous operation of multiple harmonic-producing loads.

## 6. THD OF CURRENT PROFILE

**Table 29: THD of Current Profile of EVCS**

Data Time	Current Average value of THD of Current L1(%)	Current Average value of THD of Current L2(%)	Current Average value of THD of Current L3(%)
2081-12-24 00:00:00	0	27	0
2081-12-24 00:30:00	1.4	9.3	0
2081-12-24 01:00:00	0	0.4	0
2081-12-24 01:30:00	0	8.3	0
2081-12-24 02:00:00	0	64	0
2081-12-24 02:30:00	11.3	51.7	19.5
2081-12-24 03:00:00	0	34.5	31.2
2081-12-24 03:30:00	0.1	60	65.8
2081-12-24 04:00:00	0	60	66.3
2081-12-24 04:30:00	3.9	60	66.3
2081-12-24 05:00:00	63.3	23.2	66.3
2081-12-24 05:30:00	66.3	0	52.6
2081-12-24 06:00:00	51.3	4	3.7
2081-12-24 06:30:00	11.9	12.8	12
2081-12-24 07:00:00	7.8	8.1	7
2081-12-24 07:30:00	12.5	12.2	12.3
2081-12-24 08:00:00	0.8	1	0.7
2081-12-24 08:30:00	0	0	0
2081-12-24 09:00:00	0	0	0
2081-12-24 09:30:00	0	0	0
2081-12-24 10:00:00	0	0	0

<b>Data Time</b>	<b>Current Average value of THD of Current L1(%)</b>	<b>Current Average value of THD of Current L2(%)</b>	<b>Current Average value of THD of Current L3(%)</b>
2081-12-24 10:30:00	0	0	0
2081-12-24 11:00:00	0	0	0
2081-12-24 11:30:00	0	0	0
2081-12-24 12:00:00	0	0	0
2081-12-24 12:30:00	1.4	1	0.8
2081-12-24 13:00:00	0	7	4.5
2081-12-24 13:30:00	0	0	0
2081-12-24 14:00:00	0	0	0
2081-12-24 14:30:00	0	0	0
2081-12-24 15:00:00	0	0	0
2081-12-24 15:30:00	0	0	0
2081-12-24 16:00:00	0	0	0
2081-12-24 16:30:00	0	0	0
2081-12-24 17:00:00	0	0	0
2081-12-24 17:30:00	0	0	0
2081-12-24 18:00:00	6	6.9	6.1
2081-12-24 18:30:00	17.9	19.1	20.1
2081-12-24 19:00:00	14.6	13	14.1
2081-12-24 19:30:00	9.8	10.1	8.9
2081-12-24 20:00:00	9.1	9.4	8.2
2081-12-24 20:30:00	9	9.3	7.9
2081-12-24 21:00:00	9	9.4	8.1
2081-12-24 21:30:00	8.1	8.4	7.2
2081-12-24 22:00:00	11.1	11.4	10.2
2081-12-24 22:30:00	13	13.8	12.3
2081-12-24 23:00:00	6.4	24	10
2081-12-24 23:30:00	22.5	32.9	34.3

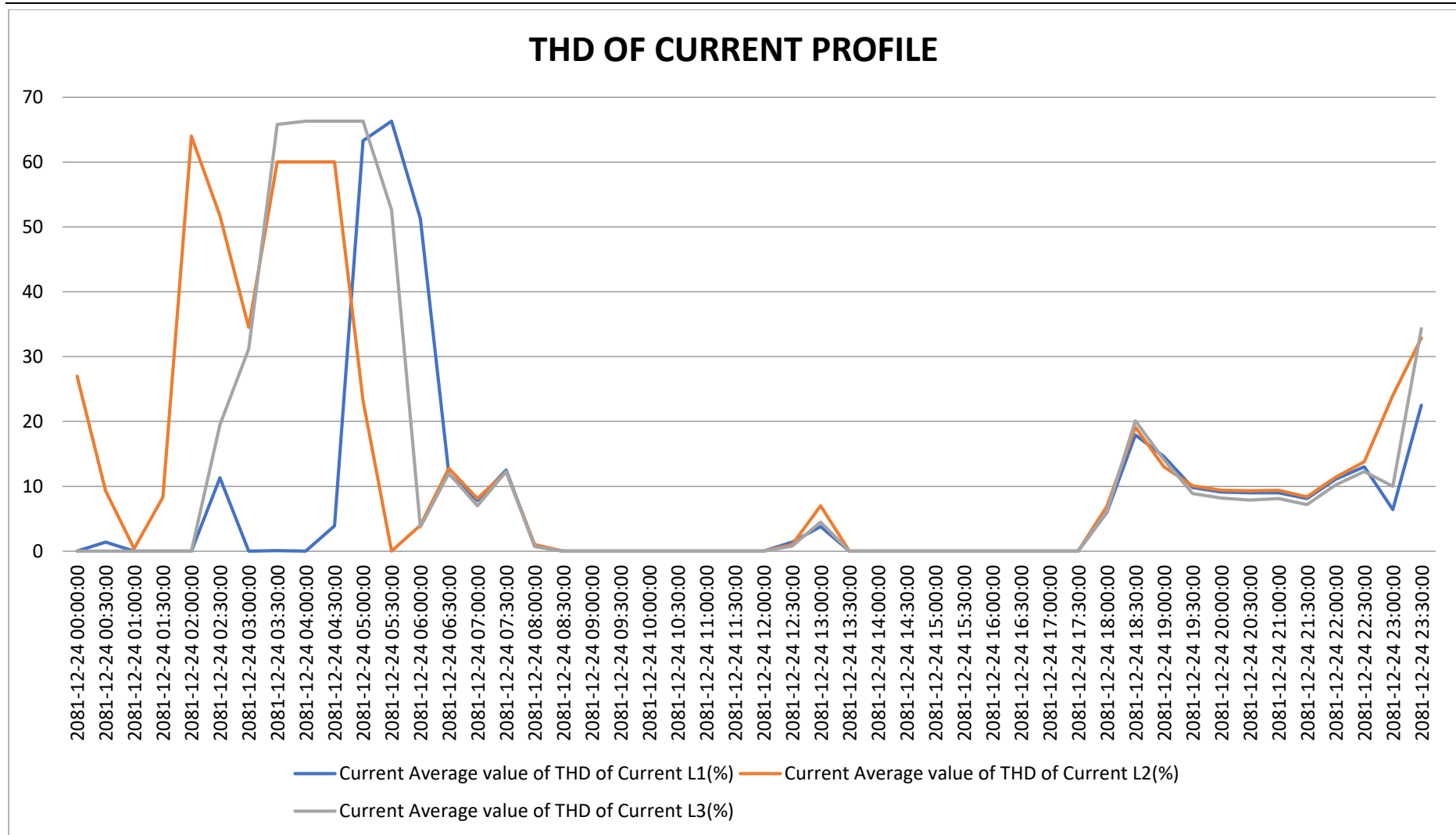


Figure 22 : THD of Current Profile of EVCS

The graph displays the Total Harmonic Distortion (THD) of current for three phases (L1, L2, L3) over a 24-hour period on December 24, 2081. THD is a key indicator of power quality, with high values potentially causing equipment malfunction, increased losses, and grid instability.

### **Significant THD Spikes:**

Between 00:00 and 06:00, all three phases (L1, L2, L3) show very high THD values, frequently exceeding 60%.

After 06:00, THD values drop sharply and remain low for the majority of the day.

Another moderate increase in THD is observed after 21:00, with values rising above 20% for all three phases.

### **Phase Comparison:**

The THD profiles for all three phases are similar, with L2 and L3 showing a slightly higher and more prolonged peak than L1 during the early hours.

After the initial spike, all three phases track closely together, indicating a systemic issue rather than a phase-specific one.

### **Implications for the Grid**

#### **Power Quality Concerns:**

- THD values above 5% are generally considered problematic for sensitive equipment and can indicate substantial harmonic pollution in the grid.
- The observed spikes (up to 60-70%) are extremely high and could lead to:
  - Overheating of transformers and motors
  - Malfunction or reduced lifespan of sensitive electronics
  - Increased losses in the distribution network

#### **Time-Based Impact:**

The most severe harmonic distortion occurs during the early morning hours, possibly due to non-linear loads or specific industrial processes operating during this period.

The late evening rise suggests another period of high harmonic activity, potentially linked to load changes or switching events.

#### **Systemic Nature:**

The similarity across all three phases indicates that the harmonic distortion is likely caused by a common source or a widespread issue affecting the entire system rather than isolated loads.

### **Recommendations**

- Investigate Sources of Harmonics:

- Identify and analyze major non-linear loads (e.g., variable frequency drives, UPS systems, large-scale rectifiers) operating during the affected periods.

**Mitigation Measures:**

- Consider installing harmonic filters or upgrading equipment to handle higher harmonic content.
- Implement time-based monitoring and control strategies to limit the operation of high-harmonic-producing equipment during sensitive periods.
- Continuous Monitoring:
- Maintain ongoing THD monitoring to quickly identify and address future spikes.

**Conclusion**

The grid experiences severe harmonic distortion during specific periods, posing a risk to power quality and equipment reliability. Immediate investigation and mitigation are recommended to maintain grid stability and protect connected assets.

#### 4.4 STANDARDS AND SPECIFICATION OF EQUIPMENT/PRODUCT TO BE USED IN EV PCI/S

##### 4.4.1 Standards of Equipment to be used in EV PCI/s

Standards of equipment used in EV public charging infrastructure (PCI/S) ensure reliability, safety, and compatibility across different charging networks.

##### 4.4.1A. IS Standard for Products responsible by different manufacturer for EVPCI/ station. IEC Standard for Products responsible by different manufacturer

Standards	Description
IS 17017: Part 2: Sec 1: 2020	Electric Vehicle Conductive Charging System - Part 2 Plugs, Socket-Outlets, Vehicle Connectors, and Vehicle Inlets - Section 1 General requirements
IS 17017 : Part 1 : 2018	Electric Vehicle Conductive Charging System Part 1 General Requirements
IS 17017 : Part 2 : Sec 7: 2023	Electric Vehicle Conductive Charging System Part 2 Plugs, Socket-Outlets, Vehicle Connectors and Vehicle Inlets Section 7 Dimensional Compatibility and Interchange Ability Requirements for a.c., d.c. and a.c. /d.c. Pin and Contact-Tube Vehicle Couplers Intended to be used for a.c./d.c. EV Supply Equipment where Protection Relies on Electrical Separation .
IS 17017 : Part 2 : Sec 3 : 2020	Electric Vehicle Conductive Charging System Part 2 Plugs, Socket-Outlets, Vehicle Connectors and Vehicle Inlets - Section 3 Dimensional compatibility and interchangeability requirements for d.c. and a.c./ d.c. pin and contact-tube vehicle couplers
IS 17017 : Part 2 : Sec 6 : 2021	Electric Vehicle Conductive Charging System -- Part 2 Plugs, Socket — Outlets, Vehicle Connectors and Vehicle Inlets -- Section 6 Dimensional compatibility requirements for DC pin and contact — tube vehicle couplers intended to be used for DC EV supply equipment where protection relies on electrical separation
IS 17017 : Part 21 : Sec 1 : 2019/IEC 61851-21-1 : 2017	Electric Vehicle Conductive Charging System Part 21 Electromagnetic Compatibility ( EMC ) Requirements Section 1 On-board chargers
IS 17017 : Part 21 : Sec 2 : 2019/IEC 61851-21-2 : 2018	Electric Vehicle Conductive Charging System Part 21 Electromagnetic Compatibility ( EMC ) Requirements Section 2 Off-board chargers
IS 17017 : Part 22 : Sec 1 : 2021	Electric Vehicle Conductive Charging Systems - Part 22 A.C. Charging Configurations - Section 1 A.C. charge point for light electric vehicle
IS 17017 : Part 23 : 2021 (IEC 61851-23:2023)	Electric Vehicle Conductive Charging Systems dc Electric Vehicle Supply Equipment

<b>Standards</b>	<b>Description</b>
IS 17017 : Part 24 : 2021	Electric Vehicle Conductive Charging System Part 24 : Digital Communication between a DC Electric Vehicle Supply Equipment and an Electric Vehicle for control of DC Charging
IS 17017 : Part 25 : 2021	Electric Vehicle Conductive Charging System -- Part 25 D.C. EV Supply Equipment where Protection Relies on Electrical Separation
IS 17017 : Part 31 : 2024	Electric Vehicle Conductive Charging System Part 31 a.c. or d.c. Ev Supply Equipment for Where Protection Relies on Electrical Separation
IS 17017 : Part 22 : Sec 1 : 2021	Electric Vehicle Conductive Charging Systems - Part 22 A.C. Charging Configurations - Section 1 A.C. charge point for light electric vehicle
ISO 15118 Series	communication between Electric Vehicles (EV), including Battery Electric Vehicles and Plug-In Hybrid Electric Vehicles, and the Electric Vehicle Supply Equipment (EVSE)
IS 732 : 2019	Code of Practice for Electrical Wiring Installations ( Fourth Revision )
IEC TR 60668:1980	Dimensions of panel areas and cut-outs for panel and rack-mounted industrial-process measurement and control instruments
OCPP 1.6	Open Charge Point Protocol (OCPP) 1.6 or latest version

#### 4.4.2B. IEC Standard for Products responsible by different manufacturer for EVPCI/ Station.

S. N	Existing International Standards	Application of use
1.a	IEC 61851 series (IEC 61851-1, IEC 61851-21-1, IEC 61851-21-2, IEC 61851-23, IEC 61851-24), IEC 62955 and Bharat Charger AC001 and DC001	For all types of AC/ DC Charging station
1.b	IEC 61851-3 series (IEC 61851-3-1, IEC 61851-3-2, IEC 61851-3-3, IEC 61851-3-4, IEC 61851-3-5, IEC 61851-3-6, and IEC 61851-3-7)	Light electric vehicles like an e-bike, e-kick scooter, and Mopeds—General requirements battery swap, communication, voltage converter, and battery system
1.c	IEC TS 61851-23-1	Pantograph charging for e-buses, trucks, etc.
2.a	IEC 62196 series (IEC 62196-1, IEC 62196-2, IEC 62196-3, IEC 62196-3-1 IEC 60309-1, -2, and IEC TS 62196-4)	Charging inlets, sockets, and EV Plugs (CGs)- dimensional compatibility and interchangeability
2.b	IEC 62752	In-cable control and protection device for mode 2 charging
3	IEC 62893-1 and IEC 62893-2	Cables including liquid-cooled cables
4	IEC 61439-7 and IEC 60364-7-717	Low voltage switchgear and control gear assemblies of EVCS
5	IEC 61540, IEC 62752, IEC 61008, IEC 61508, ISO 17409, IEC 61140, IEC 61009, and IEEE 519-2014	Functional safety and protection requirements, personnel protection circuits requirements, and power quality standards
6	IEC 61980 series (IEC 61980-1, IEC 61980-2, and IEC 61980-3) and ISO PAS 19363	Wireless charging system (general, communication and magnetic power transfer)
7	IEC 62840 series (IEC TS 62840-1 and IEC 62840-2)	Battery swapping process (General and safety requirements)
8	IEC 61851-21-1, IEC 61851-21-2, IEC 61000-6 series (IEC 61000-6-1, IEC 61000-6-2, IEC 61000-6-3, and IEC 61000-6-4), IEC 61000-3-12, AIS 138-1, and AIS 138-2	EMC related evaluations (harmonics, emission, and immunity tests)
9	IEC 61851-24, CHAdeMO, DIN 70121, DIN 70122 and ISO 15118 series (ISO 15118-1, ISO 15118-2, ISO 15118-3, ISO 15118-4, ISO 15118-5, ISO 15118-6, ISO	Digital communication for AC/DC EVCS and EV (includes V2G)

S. N	Existing International Standards	Application of use
	15118-7, and ISO 15118-8)	
10	Open charge point protocol (OCPP version 2.0.1), IEC 6274610-1 (Open ADR 2.0) and IEC 63110-1 ed.1	Communication between EVCS and utility. Used in peak load management in utilities
11	IEEE 2030.5 (Smart Energy Profile-SEP)	Communication standard between smart grid and customers

#### 4.4.3C. Products responsible by different manufacturer:

Location	Companies	Products
India	Delta Electronics India	EV charging equipment including: AC Charger: Type-1, Type-2, Type-2 Socket   Power Output – 3.12 kW to 22 kW DC Charger – CCS, CHAdeMO, DC001   Power Output – 15 kW to 150 kW
	Servotech Power Systems	EV Charging Equipment including both AC Chargers and DC Chargers: Two Charger Variants 60kW and 120 kW
	ABB India	EV charging equipment including: AC Charger: Type-1, Type-2, Type-2 Socket   Power Output – 3 kW to 22 kW DC Charger – CCS, CHAdeMO   Power Output – 11 kW to 350 kW+
	Quench Chargers	EV charging equipment including: AC Charger: Type-2, Power Output – 7.5 kW to 22 kW DC Charger – CCS, CHAdeMO   Power Output – 30 kW to 240 kW
China	Electrly	- 2*7 kW / 2*11 kW / 2*22 kW, Level 2 - 60-240 kW, Level 3
	NIO	AC: 7kW – 20kW DC: upto 180kW and 250 amps
American	Tesla	DC: 72kW - 250 kW

Source: <https://electrly.com/ev-charging-business/best-ev-charger-manufacturers-in-china> and other online sources

#### 4.4.2 Specifications of Equipment to be used in EVs PCI

Specifications of equipment used in EV public charging infrastructure (PCI) are crucial for ensuring compatibility, safety, and efficient operation.

##### 4.4.2A. Main features of WECS's charging station

Parameters	Description
Selected types of EV charger for EVCS	Category 1: GB/T (120 kW) + CCS 2.0 (60 kW) + GB/T (60 kW) + CHAdeMO (60 kW) +Type-2 AC (22 kW) +7.4 kW,Type-1AC+ 3.4kW Type-1AC Category 2: CCS 2.0 (60 kW) + GB/T (60 kW+ CHAdeMO (60 kW) + Type-2 AC (22 kW) + 3.4kW Type-1AC Category 3: GB/T (60 kW) + CCS 2.0 (60 kW) + GB/T AC (22 kW) +3.4kW Type-1AC
Energy Transfer Mode	Conductive
Charging Mode	CHAdeMO - mode 4 - DC Fast Charging CCS 2.0 – mode 4 – DC fast charging , GB/T – mode 3 (AC) and mode 4 (DC fast charging) Type-2 AC – mode 3
Reliability and Serviceability	Modularity, self-diagnostic features, fault codes and easy serviceability in the field
AC Supply System	380-480 V
Charge control communication	Communicate by digital and analog signal
Interface inter-operability	Inter-operable with any EV supporting CCS or CHAdeMO or GB/T or AC Type-2 (for each gun respectively)
AC Supply System	AC Supply System m (3Ph+N+E)
Nominal Input Voltage	3-Phase 400V
Input Frequency	50 Hz, +/- 3 Hz
No. of Outputs	3
Output Connectors	3 output connectors
Output Connector Compatibility	CCS: IEC 61851-23/24, IEC 62196-3, DIN 70121 CHAdeMO: IEC 61851-23/24, JEVS G 105, Rev. 1.2 compliant GB/T: GB/T 20234, IEC 62196-3 (for DC) and IEC 62196-2 (for AC) AC: IEC 61851-22, IEC 62196-2 Mode 3, Type 2
Converter Efficiency	> 95% at nominal output power
Ingress Protection	IP55

Parameters	Description
Communication between EVSE and Vehicle	As specified by CCS, GB/T and CHAdeMo Protocols
Communication interface between charger and central management system	All of: Ethernet, Wi-Fi and 2G/3G/4G/5G
Communication between EVSE and Central Server	Open Charge Point Protocol (OCPP) 1.6 or higher version compatible with OCPP 1.6. Metering: Grid Responsive Metering

#### 4.4.2B. AC Chargers and their Technical Parameters

Technical Parameters	
<b>Electrical</b>	
Charging Capacity	1.3kW – 7.4kW / 4.1kW – 22kW
Charge Mode	Mode 3 (IEC 61851-1)
Output Power	Selectable 1-phase or 3-phase, 230-400V 6A -32A, 50-60Hz
Socket Type	Type 2 Socket
<b>Protection and certification</b>	
Build-in RCD	DC6mA leakage sensor built-in
Socket	IP65, IK10
Operating Temperature	-25~+55°C
Compliance	EC61851-1, IEC61851-21-2, IEC61000-4, CE EMC EU/2014.CE Low Voltage EU/2014/35
Certificate	CE, UKCA, CB, RCM
<b>Connectivity</b>	
Authorization	Auto-start standard / RFID card option
Status Indication	LED ring
WLAN Communication	Wi-Fi / Bluetooth 4.2 option
Charging Protocol	OCPP1.6-J
<b>Mechanical</b>	
Housing	Plastic
Dimension	W278 x H360 x D152 mm
Mounting	Wall or Pole
<b>WIFI</b>	
Operating Frequency Range	2412 - 2484MHz
WI-FI Protocols	IEEE 802.11 b/g/n
Channels	13

<b>Technical Parameters</b>	
TX Power	<20dbm
EIRP	0.459
TX bandwidth	20MHz/40MHz
Modulation type	OFDM & DSSS
Transmitting Duty Cycle	10%
<b>BlueTooth BLE</b>	
Sensitivity @30.8% PER	-93 dbm
Co-channel C/I	+10db
RF Power Control Range	-12 ~ 9dbm
<b>NFC</b>	
Modulation Type	

Source: Beny EV Charger, China

#### 4.4.2C. EV Charger 3.7 kW and their Specification separately.

<b>Portable AC Charger</b>	<b>BCPP-A1-16</b>
	<b>European Standard</b>
Maximum Power	3.7kW
Input Voltage/ Output Voltage	AC230V 1-Phase
Charging Current range	8A-16A
Frequency	50HZ/60HZ
Display	OLED Screen + LED Light
DLB	without
Wall-mounted	without
Adjustable Current	Standard
Timed Charging	Standard
Plug options	Standard
Weekly Reservation Charging	without
History Charging Records	without
Bluetooth	without
WIFI	without
APP	Without
CP Signal Abnormal Protection	Standard
Over Voltage Protection	Standard
Under Voltage Protection	Standard
Over Current Protection	Standard
Leakage Protection	Standard
Categorization	Standard
Over Temperature Protection	Standard
Relay Adhesion Protection	Standard
Lightning Protection	Standard

<b>Portable AC Charger</b>	<b>BCPP-A1-16</b>
Fire Protection	Standard
Anti-pressure Protection	Standard
Ground Protection	Standard
Working Life	<10000 times
Plug Cable Length	1m
Total Length	7m as standard (Customized length available)
IP Protection	IP66
Operating Temperature	-30°C to +50°C
Storage temperature	-40 °C-85°C
Operating Altitude	<2000m

Source: Beny EV Charger, China

### Plug Types

	<b>EU(German)</b>	<b>AU</b>	<b>ZA</b>	<b>UK</b>	<b>BRA</b>
Model Type	ZH-3	YP-39A	ZH-70A	YP-61A	ZH-72B
Current/ Voltage	16A/250V~	20A/250V~	16A/250V~	13A/250V~	16A/250V~
Wire	H07BZ5-F3G 2.5mm <sup>2</sup>	H05VV-F3G 2.5mm <sup>2</sup>	H07RN-F3G 2.5mm <sup>2</sup>	H05VV-F3G 2.5mm <sup>2</sup>	H07RN-F 3G 2.5mm <sup>2</sup>
Material	P.V.C	P.V.C	P.V.C	P.V.C	P.V.C

Source: Beny EV Charger

#### 4.4.2D. EV Charger 7.4kW and their Specification separately.

<b>Portable + Wall -mounted</b>	<b>BCPP-A2N-32</b>
	<b>European Standard</b>
Maximum Power	7.4kw
Input Voltage/ Output Voltage	AC230V 1-Phase
Charging Current range	6A-32A
Frequency	50HZ/60HZ
Display	4.3-inch touch Screen + LED Light
DLB	Optional
Wall-mounted	Standard
Adjustable Current	Standard
Timed Charging	Standard
Plug options	Standard
Weekly Reservation Charging	Standard
History Charging Records	Standard
Bluetooth	Standard

<b>Portable + Wall -mounted</b>	<b>BCPP-A2N-32</b>
	<b>European Standard</b>
WIFI	Standard
APP	Standard
CP Signal Abnormal Protection	Standard
Over Voltage Protection	Standard
Under Voltage Protection	Standard
Over Current Protection	Standard
Leakage Protection	Standard
Over Temperature Protection	Standard
Relay Adhesion Protection	Standard
Lightning Protection	Standard
Fire Protection	Standard
Over Temperature Protection	Standard
Relay Adhesion Protection	Standard
Lightning Protection	Standard
Fire Protection	Standard
Anti-pressure Protection	Standard
Ground Protection	Standard
Working Life	<10000 times
Plug Cable Length	1m
Total Length	7m as standard (Customized length available)
IP Protection	IP65
Operating Temperature	-30°C to +50°C
Storage temperature	-40 °C-85°C
Operating Altitude	<2000m

### Plug Types

	<b>EU (German)</b>	<b>AU</b>	<b>ZA</b>	<b>UK</b>	<b>BRA</b>	<b>USA</b>
Model Type	ZH-3	YP-39A	ZH-70A	YP-61A	ZH-72B	ZH-02
Current/ Voltage	16A/250V~	20A/250V~	16A/250V~	13A/250V~	16A/250V~	15A/125V
Wire	H07BZ5-F3G 2.5mm <sup>2</sup>	H05VV-F3G 2.5mm <sup>2</sup>	H07RN-F3G 2.5mm <sup>2</sup>	H05VV-F3G 2.5mm <sup>2</sup>	H07RN-F3G 2.5mm <sup>2</sup>	SJ14AWG*3C* 2.08mm <sup>2</sup>
Material	P.V.C	P.V.C	P.V.C	P.V.C	P.V.C	N.P.C-45P

**PlugTypes**

	<b>EU (German)</b>	<b>AU</b>	<b>ZA</b>	<b>UK</b>	<b>BRA</b>	<b>USA</b>
Model Type	TYPR285	TYPR281	TYPR235	TYPR231	Three-phase cable/0.9M	Three-phase cable/0.9M
Current/Voltage	32A/230V (3 Phase)	32A/230V (1 Phase)	16A/230V	16A/230V	32A/230V (3 Phase)	32A/230V (1 Phase)
Wire	H07BZ5-F 5G6mm <sup>2</sup> +1*0.75mm <sup>2</sup>	H07BZ5-F 3G6mm <sup>2</sup> +1*0.75mm <sup>2</sup>	(3 Phase)	(1 Phase)	H07BZ5-F 5G6mm <sup>2</sup> +1*0.75mm <sup>2</sup>	H07BZ5-F 3G6mm <sup>2</sup> +1*0.75mm <sup>2</sup>
Wire	H07BZ5-F 5G6mm <sup>2</sup> +1*0.75mm <sup>2</sup>	H07BZ5-F 3G6mm <sup>2</sup> +1*0.75mm <sup>2</sup>	H07BZ5-F 5G2.5mm <sup>2</sup> +1*0.75mm <sup>2</sup>	H07BZ5-F 3G2.5mm <sup>2</sup> +1*0.75mm <sup>2</sup>	H07BZ5-F 5G6mm <sup>2</sup> +1*0.75mm <sup>2</sup>	H07BZ5-F 3G6mm <sup>2</sup> +1*0.75mm <sup>2</sup>

Source: Beny EV Charger, china

**4.4.2E. EV Charger 22kW and their Specification separately.**

<b>Floor Mounted AC EV Charger</b>	<b>BCPCV-DT2N-P</b>	<b>BCPCV-CT2N-P</b>
Maximum Power	22Kw (2 GUN)	22Kw (2 GUN)
Input Voltage/ Output Voltage	AC400V 3-Phase	AC400V 3-Phase
Input Frequency	50/60Hz	
Tethered/ Socket	Socket	Tethered
Meter	Built-in Electric Meter	
Display	Five-inch LCD Screen + LED Lights	
Charging Protocol	OCPP1.6-J	
Incoming line method	Single Input	
Rate Charging Current	2x(6-32A)	
T2S Socket	Optional	Without
RFID	Standard	Standard
DLB	Optional	Optional
Wi-Fi	Standard	Standard
Ethernet	Standard	Standard
Bluetooth	Standard	Standard
4G	Optional	Optional
Over Voltage & Under Voltage Protection	Standard	Standard
Emergency Stop	Standard	Standard
Over Current Protection	Standard	Standard
CP Signal Short Circuit Protection	Standard	Standard

<b>Floor Mounted AC EV Charger</b>	<b>BCPCV-DT2N-P</b>	<b>BCPCV-CT2N-P</b>
Over Temperature Protection	Standard	Standard
Lightning Protection	Standard	Standard
Contractor Adhesion Protection	Standard	Standard
Length of gun cable	/	5M
Protection Degree	IP55	
Environment Temperature	-30°C to +55°C	
Charger Dimension	350mmx220mmx1422mm	
Maximum Altitude	<2000m	

Source: Beny EV Charger, china

#### 4.4.2F. EV Charger DCFC 60 kW and their Technical Parameters/ Specification separately.

<b>DC EV Charging Station</b>	<b>BDC 60-D</b>	<b>BDC 90-D</b>	<b>BDC 120-D</b>
<b>Structure Description</b>			
Shell Material	Sheet Metal		
Dimension	800*800*1800(L*W*T)		
Weight	<500kg		
Installation Method	Floor -Stand Type		
Cable Routing	Bottom Inlet Wiring. Up Outlet Wiring		
Cable Length	5M		
Charging Outlets	Double (CCSI+CCSI) Double (CCSI+CHADEMO) Double (CCS2+GBT) Double (CHADEMO+CHADEMO)	Double (CCS2+CCS2) Double (CCS2+CHADEMO) Double (CHADEMO+GBT)	Double (CCS1+CCS2) Double (CCS1+GBT) Double (GBT+GBT)
Connectivity Authorization	RFID,App		
Screen	9.1 InchLCD Screen/LEDLight		
<b>Electrical Specification</b>			
Ac Input Voltage	AC380V±15%,3P+N+PEAC		
Input Frequency	50HZ/60HZ		
Consumption	<24W		
Rated Power	60kW	90kW	120kW
Output Voltage Range	CCS1/CCS2/GBT:150Vdc-1000Vdc:CHADEMO:150Vdc-500Vdc		
Output Current	CCS1/CCS2/GBT:0-250A;CHADEMO:0-125A		
Efficiency	>95%		
PowerFactor	>0.99(Load:100%)		
<b>Functionate Design</b>			

DC EV Charging Station	BDC 60-D	BDC 90-D	BDC 120-D
User Interface	Emergency Stop Button, LED Indicator, Card Swiping, Touch Screen		
Charging Stands	IEC61851-21-2:2021;IEC61000-6-2-2019;EN61000-6-4:2019;IEC61851-1:2019;EN61851-23:2014		
<b>Communication</b>			
OCP	OCP1.6J		
Network Interface	Ethernet/4G		
<b>Environment Condition</b>			
Application Place	Indoor/Outdoor		
Working Latitude	<2000m		
Working Temperature	30°C~+50°C		
Working Humidity	5%-95%		
Protection Level	IP55		
Natural Cooling	Forced-air Cooling		
MTBF	24 Months Warrantry		
Security Design	Over/Under Voltage Protection, Overlord Protection, Current Leakage Protection, Grounding Protection, Lightning Survey Protection		

Source: Beny EV Charger, china

#### 4.4.2G. EV Charger DCFC 120 kW and their Technical Parameters/ Specification separately

DC EV Charging Station	BDC120-S
<b>Structure Description</b>	
Shell Material	Sheet Metal
Dimension	800*800*1800(L*W*T)
Weight	≤450kG
Installation Method	Floor-Stand Type
Cable Routing	Bottom Inlet Wiring Up Outlet Wiring
Cable Length	5 M
Charging Outlets	Single (CCS1/CCS2/GBT/CHADEMO)
Connectivity Authorization	RFID, App
Screen	9.1 Inch LCD Screen/LED Light
<b>Electrical Specification</b>	
AC Input Voltage	AC380V±15% ,3P+N+PEAC
Input Frequency	50Hz/60Hz
Consumption	≤24wh
Rated Power	120kW
Output Voltage Range	150Vdc - 1000Vdc
Output Current	CCS1/GBT: 0-250A CCS2: 0-200A CHADEMO: 0-125A
Efficiency	≥95%

<b>DC EV Charging Station</b>	<b>BDC120-S</b>
Power Factor	≥0.99 (load: 100%)
<b>Functional Design</b>	
User Interface	<b>Charger protection (As per IEC Standard/ manufacturer )</b>
Charging Stands	IEC 61851-21-2:2021; IEC 61000-6-2:2019; EN61000-6-4:2019; IEC 61851-1:2019; EN 61851-23:2014; EN 61851-24:2014
<b>Communication</b>	
OCP	OCP 1.6J
Network Interface	Ethernet/4G
<b>Environment Condition</b>	
Application Place	Indoor/Outdoor
Working Latitude	<2000m
Working Temperature	-30 °C ~ +50 °C
Working Humidity	5%-95%
Protection Level	IP55 /IP65
Natural Cooling	Forced-air Cooling
MTBF	24 Months Warranty
Security Design	Over/Under Voltage Protection, Overload Protection, Current Leakage Protection, Grounding Protection Over Temp Protection, Lightening Surge Protection

Note: Other technical specifications of EV charger type 52kW, 82kW, 90kW, 112kW, 150kW, 172kW, 180kW, 202kW, 240kW, 262kW and their plug types are provided in the Annex III.

Source: Beny EV Charger, China

## 4.5 IDENTIFICATION OF THE OPTIMUM NUMBER AND SUITABLE LOCATIONS OF EVPCI/S

### 4.5.1 Highway Selection as per SNH 2020/2021

For selection of a national highway, AHP is a step-by-step process to choose a national highway using the method that helps make the best decisions based on many factors. First, the goal is clearly defined to choose the most appropriate highway. Subsequently, important factors such as cost, environmental impact, social impact, construction challenges and traffic status are identified. A questionnaire is designed to gather opinions from experts, such as engineers, government officials and members of the local community. They rank the importance of a simple scale and compare different factors in pairs. Their reactions are then used to create a comparison table, which helps to calculate how important each factor is. A stability test is done to ensure that the reactions are reliable. After that, separate highways are made on the basis of these weighted factors, and the highest scores are chosen as the best option. This process ensures that the highway is chosen based on clear evaluation of facts, expert statements and all possible effects, leading to a well-informed and balanced decision. Highway Selection is based on 6 different criteria as mentioned below.

1. Population Density
2. Traffic Volume
3. Accessibility to cities
4. Availability of Power Supply
5. Industries/Tourism/Religious/Historical
6. Future Development Potential

**Weightage is calculated using AHP and following results were obtained;**

<b>Weight Considering All questionnaire (Option 1)</b>		
<b>Variables</b>		<b>Average Weight From AHP</b>
Population Density	PD	<b>0.1206</b>
Traffic Volume	TV	<b>0.1851</b>
Accessibility to cities	AC	<b>0.1583</b>
Industries/ Tourism/ Religious/ Historical	IH	<b>0.1455</b>
Infrastructure to Power Supply Availability	PS	<b>0.2272</b>
Future Development Potential	FD	<b>0.1633</b>

### **Weight Checking compatibility with respect to Traffic Volume as important factor (Option 2)**

<b>Variables</b>		<b>Average Weight From AHP</b>
Population Density	PD	<b>0.1078</b>
Traffic Volume	TV	<b>0.3006</b>
Accessibility to cities	AC	<b>0.1690</b>

<b>Variables</b>		<b>Average Weight From AHP</b>
Industries/Tourism/Religious/Historical	IH	<b>0.1092</b>
Infrastructure to Power Supply Availability	PS	<b>0.2311</b>
Future Development Potential	FD	<b>0.0822</b>

<b>Weight (Checking compatibility of Volume and others as well) (Option 3)</b>		
<b>Variables</b>		<b>Average Weight From AHP</b>
Population Density	PD	<b>0.1476</b>
Traffic Volume	TV	<b>0.2316</b>
Accessibility to cities	AC	<b>0.1734</b>
Industries/Tourism/Religious/Historical	IH	<b>0.1352</b>
Infrastructure to Power Supply Availability	PS	<b>0.1891</b>
Future Development Potential	FD	<b>0.1231</b>

Note: AHP calculation sheet is attached in Annex IX

From the discussions made with the team experts and literature reviews, **Option 3** has been adopted for further analysis work. Further, the ranking was developed using the selected weightage of all 80 NHs, which has been shown in detailed in table below.

Table 30: Ranking of 80 National Highways

Highway Code	Names	Weighted Popn Density	Average Traffic Vol.	Access Population	Industry Tourism Religious historical	Power Supply Availability	Future Dev Index	Weightage average	Rank
NH01	Existing East-West Highway	457	15641	5245	16	1	0.484596	0.357	8
NH02	Kechana-Chandragadhi-Charali-Ilam-Phidim, Ganeshchok- Taplejung-Olanchungola (Mechi Rgmarg)	228	4033	1227	4	1	0.507012	0.252	25
NH03	Pushpalal Mid Hill Highway	176	1461	1290	36	1	0.46301	0.352	10
NH04	Birtamod-Chandragadi-Bhadrapur-Mechi Pul	1174	7895	7746	0	1	0.518	0.287	16
NH05	Postal Highway	589	6764	3400	31	1	0.482873	0.371	7
NH06	Chatara-Mulghat-Majhitar-Amarapurdanda-Ganeshchok (Tamor Corridor)	130		1716	2	1	0.507644	0.229	44
NH07	Pakali-Naya Koshipul-Rupnagar, Pakali-Nadaha Koshipul Chatara	408		2266	0	1	0.482816	0.222	55
NH08	Rani-Biratnagar-Itahari-Dharan-Dhankuta-Hile, Leguwaghat-Tumlingtar-Khandbari-Num-Kimathanka (Koshi Rajmarg)	394	14255	2585	3	1	0.495143	0.296	15
NH09	Bahundangi-Shantinagar-Dharan-Chatara-Ghaighat-Katari Sindhulimadi-Hetauda-Gaidakot-Rampur-Ramdi-Ridi-Balkot-Sandhikharka-Bijuwar-Sitalpati-Surkhet-Baddichaur-Sahajpur-Budar- Jogbudha-Rupal (Madan Bhandari Rajmarg)	208	9532	1957	13	1	0.467497	0.303	14
NH10	Deurali-Mudhe-Chainpur-Bohoratar	125	398	1086	0	1	0.489016	0.216	61

Highway Code	Names	Weighted Popn Density	Average Traffic Vol.	Access Population	Industry Tourism Religious historical	Power Supply Availability	Future Dev Index	Weightage average	Rank
NH11	Phikkal-Shreeantu-Chabbise, Ilam	217		2880	2	1	0.526	0.237	32
NH12	Ghurmi-Chatara Udayapur	123		2009	2	1	0.481699	0.225	53
NH13	Bardibas-Sindhuli-Khurkot-Dhulikhel (B.P. Rajmarg)	190	8004	1911	1	1	0.459391	0.250	34
NH14	Gaighat-Mahuli Khola-Rupani-Rajbiraj-Chhinamasta Niur, Kunauli-Rajbiraj-Kanchanpur Barrier-Phattepur-Basaha Udayapur	646		2867	1	1	0.440363	0.222	67
NH15	Gwarko-Lubhu-Lakuribhanjyang-Kushadevi-Panauti-Dahaltar	399	38088	4688	7	1	0.621869	0.446	3
NH16	Thadi-Bhagawanpur-Lahan, Kadmahachok-Gaighat-Mohure-Kharpa-Solu	240	4137	2627	2	1	0.468146	0.241	39
NH17	Naubise-Mugling-Pokhara (Prithvi Rajmarg)	320	12653	4684	18	1	0.499575	0.352	9
NH18	Balaju-Trishuli-Dhunche-Syaphrubesi	471	7155	19480	6	1	0.479171	0.325	13
NH19	Ridi-Balkot-Hanshpur-Pyuthan, Pyuthan-Surkhet Road	234		749	2	1	0.467748	0.219	62
NH20	Madar-Chauharwa, Mirchaiya-Katari-Ghurmi, Hilepani-Okhaldhunga-Salleri	247	2930	1546	3	1	0.466667	0.236	45
NH21	Sitapaila-Dharke	1689	14884	40743	6	1	0.527505	0.446	4
NH22	Dhalkebar-Janakpur-Jatahi, Ghorghans-Nimchaur-Thalahighat-Akraharghat	1270	8700	5117	6	1	0.431	0.289	19
NH23	Diktel-Solu-Junbesi-Khahare-Jiribazar-Tamakoshi -Charikot-Khadichaur	118	888	573	2	1	0.479794	0.222	56

Highway Code	Names	Weighted Popn Density	Average Traffic Vol.	Access Population	Industry Tourism Religious historical	Power Supply Availability	Future Dev Index	Weightage average	Rank
NH24	Lalgadh-Ranibas (R.T.O. Road)- Bishmat-Bahunmara-B.P. Rajmarg	230		2449	0	1	0.433238	0.210	77
NH25	Dumre-Beshisahar-Chame	138	6500	1174	1	1	0.522256	0.253	24
NH26	Jamunibas-Bateshwar- Shantipur-Kurtha-Janakpur	1033		10240	2	1	0.426834	0.249	40
NH27	Shitalpati Salyan Kubhinde Baluwa Sangrahi		1540	867	1	1		0.126	80
NH28	Bhittamod-Jaleswor-Bardibas, Khurkot-Manthali-Tamakoshi- Singati-Lamagagar-Lapchegaun	346	2664	1077	5	1	0.441699	0.238	49
NH29	Kanchanban-Janaki Medical College-Mithileshwar Sabaila- Siraha-Naktajjh-Ramlaxman Chowk-Healthpost Mahendra Rajmarg	772		6788	6	1	0.431	0.252	35
NH30	Janakpur (Mujeliya) Dhanushadham-Dharapani Ramayan Circuit, Tarapatti- Pathara-Ma. Ra.Ma. – Pushpalpur	1047	670	7913	6	1	0.431	0.260	31
NH31	Dolalghat-Chautara	258	815	1707	1	1	0.455	0.218	68
NH32	Nawalpur-Malangawa- Sonbarsha	973	3407	4032	1	1	0.402	0.234	59
NH33	Nijgadh-Kathmandu	721		6189	6	1	0.526582	0.268	20
NH34	Kathmandu-Dhulikhel- Dolalghat-Khadichaur-Kodari (Arniko Rajmarg)	1810	29566	12466	11	1	0.499541	0.440	5
NH35	Piluhawa Manmat - Kalaiya – Martihawa	1031		10541	2	1	0.457	0.256	29
NH36	Chandranigahpur-Gaur	1105	6724	2478	0	1	0.5123	0.380	21

Highway Code	Names	Weighted Popn Density	Average Traffic Vol.	Access Population	Industry Tourism Religious historical	Power Supply Availability	Future Dev Index	Weightage average	Rank
NH37	Hetauda-Bagmati-Tikabhairav-Bhaisepati-Ekantakuna (Kanti Rajpath)	895		7414	5	1	0.6412	0.293	12
NH38	Kathmandu Outer Ringroad	4528		40603	11	1	0.657481	0.463	2
NH39	Kathmandu Ringroad	12088	53912	58639	11	1	0.673675	0.844	1
NH40	Samakhushi-Tokha-Gurje-Bidur	2674		4801	1	1	0.5365	0.406	17
NH41	Sirsiya-Pathlaiya, Hetauda-Bhaise-Palung-Naubise-Kathmandu (Tribhuvan Rajpath)	964	10616	11228	8	1	0.497313	0.332	11
NH42	Thori-Bhandara-Malekhu, Galchi-Trishuli-Betrawati-Mailung-Syaphrubesi-Rasuwadhi	182	4484	1346	1	1	0.485595	0.238	37
NH43	Malekhu-Dhading-Salyantar	264	1877	1534	0	1	0.461	0.220	64
NH44	Thori-Bharatpur-Mugling, Aanbukharieni-Gorkha-Ghyampesal, Aarughat-Sirdibas-Roila	268	10515	1557	3	1	0.500826	0.276	18
NH45	Khairenitar Bhimad Kawasoti	208		2167	1	1	0.498155	0.226	50
NH46	Bhumahi-Parasi	501		15122	0	1	0.493	0.263	23
NH47	Belahiya-Bhairahawa-Butwal-Bartung-Ramdi-Syangja-Pokhara (Siddharth Rajmarg)	514	14072	6146	19	1	0.518247	0.372	6
NH48	Tansen-Ridi-Korla	122	1856	872	8	1	0.49547	0.253	27
NH49	Bartung Tansen Ridi Wamitaksar Kharwang	220		585	0	1	0.46411	0.210	71
NH50	Jitpur-Taulihawa-Khunuwa	592	3672	6186	1	1	0.432	0.243	46
NH51	Taulihawa-Gorusinge-Sandhikharka	187	2528	2959	0	1	0.466814	0.227	54

Highway Code	Names	Weighted Popn Density	Average Traffic Vol.	Access Population	Industry Tourism Religious historical	Power Supply Availability	Future Dev Index	Weightage average	Rank
NH52	Kakarhawa(IB)-Rudrapur, Sajlhandi-Sandhikhark-Devasthan, Burtibang-Dhorpatan	272		1597	9	1	0.481817	0.251	28
NH53	Bhalubang Liwang Rolpa Madichaur Darbot	155	2371	909	2	1	0.40876	0.216	75
NH54	Koilabas-Lamahi, Arjunkholagau-Ghorahi-Holeri-Ghartigaun-Thawang-Lukum (Sahid Marg)	127	4001	1737	1	1	0.43099	0.226	65
NH55	Ameliya-Tulsipur-Shitalpti-Tharmare-Musikot	241	3851	2022	4	1	0.451437	0.242	43
NH56	Tharmare-Chaurjahari-Jajarkot Khalanga-Jumla Kudari-Mugu Rara (Rara Rajmarg)	90		988	7	1	0.407348	0.225	70
NH57	Chinchu-Kudu-Jajarkot -Dunai-Dho-Tinje-Marim (Bheri Corridor)	72		762	8	1	0.414469	0.229	63
NH58	Jamunaha-Nepalgunj-Kohalpur-Surkhet-Khulalu-Hilsa (Karnali Rajmarg)	168	5923	1558	10	1	0.41153	0.264	30
NH59	Murtiya (IB)-Gulariya-Bhurigaun-Telpani-Surkhet-Mathillo Dungeshwor-Bank-Bayuli Nagma	182	1095	2522	6	1	0.436362	0.236	52
NH60	Surkhet-Dailekh-Mahabulekh-Galje, Nagma-Gamgadhi-Nakchelagna	115	2855	807	7	1	0.409261	0.236	57
NH61	Surkhet Tallo Dundeshwor-Saatkhamba-Dullu-Pipalkot-Khulalu-Manma-Jumla Sadak	156		927	5	1	0.401489	0.217	76
NH62	Khakraula-Tikapur-Lamki-Lodeghat-Bayalpata, Saphebagar-Chainpur	200		1670	4	1	0.409984	0.218	74

Highway Code	Names	Weighted Popn Density	Average Traffic Vol.	Access Population	Industry Tourism Religious historical	Power Supply Availability	Future Dev Index	Weightage average	Rank
NH63	Saphebagar-Martadi-Kolti	154		596	4	1	0.365862	0.205	78
NH64	Khodpe-Chainpur (Bajhang)	167	642	1026	0	1	0.379359	0.195	79
NH65	Khuttiya-Dipayal-Chainpur-Uraibhanjyang	138		708	8	1	0.390469	0.225	72
NH66	Dhangadhi-Sahajpur-Budar-Syaule, Satbajh-Thaktoli-Darchula-Tinkar	213	8680	1206	6	1	0.435992	0.265	26
NH67	Chandani-Bhimdatta-Bramhadev-Pancheshwar-Jhulaghat	193		1062	2	1	0.435879	0.214	73
NH68	Bhimad-Rampur-Mityal-Arung Khola	200		1927	1	1	0.502049	0.226	48
NH69	Jagat Bhanjyang-Mandalithan-Keware Bhanjyang-Barikuna-Kishan-Chapakot-Gajarkot Sadak, Syangja	270		1749	1	1	0.526966	0.231	36
NH70	Seti Dovan-Wejang-Panchmul-Aaruchaur Ghante Deurali, Syangja	206		2181	1	1	0.520728	0.230	41
NH71	Bhaluwang-Nuwakot-Khandaha-Kharwang	174		1302	1	1	0.477188	0.218	60
NH72	Dumkibas-Baguban Triveni	69		4324	0	1	0.493	0.226	51
NH73	Surunga-Sharnamati-Tangandubba-Lasunganj, Jhapa	500		2126	0	1	0.518	0.229	42
NH74	Ilam (Biplate)-Maipokhari-Sandakpur, Ilam	127		1002	0	1	0.526	0.223	47
NH75	Sworna Sagarmatha Ringroad (Okhaldhunga-Solu-Salleri-Khotang-Diktel-Okhaldhunga)	105		927	1	1	0.485316	0.218	58
NH76	Damak-Chisapani-Rabi	343		3442	0	1	0.518443	0.231	38
NH77	Bharatpur Mahanagariya Brihat Chakrapath	826		3517	2	1	0.551	0.251	22

Highway Code	Names	Weighted Popn Density	Average Traffic Vol.	Access Population	Industry Tourism Religious historical	Power Supply Availability	Future Dev Index	Weightage average	Rank
NH78	Damak Na.Pa. Chakrapath	1362		1781	0	1	0.517135	0.239	33
NH79	Godar (Dhanusha) Chisapani-Mainawati-Kalapani-Dudhauri, Sindhuli	182		6486	0	1	0.43321	0.222	69
NH80	Mahendra Rajmarg Bastipurchowk (Siraha)-B.P. Cancer Hospital-Belsot-Katari, Udayapur	287		1984	3	1	0.443835	0.223	66

Note: List of national highways as per SNH 2020/2021 is attached in Annex V

Note: List of national highway Traffic count in PCU is attached in Annex VI

## Selection of NHs

After manually looking at Cities/ Nodes/ Importance (response from Questionnaire Survey with EV user)/Population Density/Traffic, 14913 km of National Highways has been selected as the feasible highways for establishment of charging stations in the three phases: Phase I (1-3 years), Phase II (3-6 years) and Phase III (6+ years). The selected feasible highways as shown below with their feasible length after considering the major cities location along them.

**Table 31: Selected Highways for I&II phase**

Selected NHW	Ranking conducted by AHP	Junctions (Node)	Length (km)	Metro/Sub Metrocity/District HQ/Major Cities
NH39	1	Kathmandu Ringroad	27	Gongabu, Chabahil, Koteswor(Tinkune), Balkhu (TU compound)
NH15	3	Gwarko-Lubhu-Lakuribhanjyang-Kushadevi-Panauti-Dahaltar	128	Gwarko, Lubhu, Lakhuribhanjyang, Ryale, Panauti
NH34	5	Kathmandu-Dhulikhel-Dolalghat-Khadichaur-Kodari (Arniko Rajmarg)	112	Kathmandu(Tripureswor), Bhaktapur, Dhulikhel, Dolalghat, Khadichaur, Kodari
NH47	6	Belahiya-Bhairahawa-Butwal-Bartung-Ramdi-Syangja-Pokhara (Siddharth Rajmarg)	184	Bhairahawa, Butwal, Tansen, Syangja, Pokhara
NH05	7	Bhumahi-Ramgram-Bhairahawa-Lumbini-Taulihawa	1016	Bhumahi, Ramgram, Bhairahawa, Lumbini, Taulihawa
NH01	8	Existing East-West Highway	1028	Kakarbhitta, Birtamod, Damak, Itahari, Inaruwa, Bhardaha, Kanchanpur, Lahan, Choharwa, Dhalkebar, Bardibas, Nawalpur, Chandranigahpur, Nijgadh, Pathlaiya, Hetauda, Lothar, Ratnanagar, Bharatpur, Dumkibas, Bardaghat
NH17	9	Naubise-Mugling-Pokhara (Prithvi Rajmarg)	173	Naubise, Galchhi, Malekhu, Mugling, Damauli, Pokhara
NH03	10	Diktel-Halesi-Hilepani-Ramechhap, Dailekh-Rakam-Mangalsen-Silgadhi-Dadeldhura-Baitadi-Jhulaghat	1787	Diktel, Halesi, Hilepani, Ramechhap, Dailekh, Rakam, Mangalsen, Silgadhi, Dadeldhura, Baitadi, Jhulaghat
NH41	11	Sirsiya-Pathlaiya	155	Sirsiya, Pathlaiya
NH37	12	Hetauda-Bagmati-Tikabhairav-Bhaisepati-Ekantakuna (Kanti Rajpath)	86	Hetauda, Chisapani, Tikabhairab, Bhaisepati, Ekantakuna
NH18	13	Balaju-Trisuli-Bidur	65	Balaju, Bidur

Selected NHW	Ranking conducted by AHP	Junctions (Node)	Length (km)	Metro/Sub Metrocity/District HQ/Major Cities
NH09	14	Dharan-Chatara-Beltar-Gaighat-Katari-Chadanpur-Bhiman	1200	Dharan, Chatara, Gaighat, Katari, Bhiman
NH08	15	Rani-Biratnagar-Itahari-Dharan-Dhankuta	320	Biratnagar, Itahari, Dharan, Dhankuta
NH04	16	Bhadrapur-Birtamod(EW HW)	15	Bhadrapur, Birtamod
NH40	17	Samakhushi-Tokha-Gurje-Bidur	26	Samakhushi, Tokha, Gurje
NH44	18	Bharatpur-Mugling-Gorkha	300	Bharatpur, Lugling, Gorkha
NH22	19	Dhalkebar-Janakpur-Jatahi	48	Dhalkebar, Janakpur, Jatahi
NH36	21	Chandranigahpur-Gaur	45	Gaur, Shivanagar, Chandranigahpur
NH77	22	Bharatpur Mahanagariya Brihat Chakrapath	105	Bharatpur Ring Road
NH02	25	Bhadrapur-Illam-Tamplejung	352	Bhadrapur, Illam, Phidim, Tamplejung
NH66	26	Dhangadhi-Attariya-Dadeldhura	350	Dhangadhi, Attariya, Dadeldhura
NH52	28	Kakarhawa-Tenuhawa-Pipara	222	Tenuhawa, Pipara (EW Highway)
NH35	29	Piluhawa Manmat - Kalaiya - Martihawa	25	Matiarwa, Kalaiya, Manmat (EW Highway)
NH58	30	Jamunaha-Nepalgunj-Kohalpur-Surkhet	538	Nepalgunj, Kohalpur, Chinchu, Surkhet
NH78	33	Damak Na.Pa. Chakrapath	100	Damak Ring Road
NH13	34	Bardibas-Dhulikhel	160	Bardibas, Bhiman, Sindhulimadi, Khurkot, Nepalthok, Dhulikhel
NH42	37	Galchi-Bidur-Nuwakot	197	Galchi, Bidur, Dhunche
NH16	39	Thadi-Lahan-Gaighat	144	Thadi, Lahan, Gaighat
NH55	43	Ameliya-Kapurkot-Salyan-Khalanga	169	Ameliya, Kapurkot, Salyan, Khalanga
NH20	45	Madar-Mirchaiya-Katari-Hilepani-Okhaldunga	193	Madar, Mirchaiya, Katari, Hilepani, Okhaldunga
NH50	46	Jitpur-Taulihawa-Khunuwa	30	Jitpur, Taulihawa, Khunuwa
NH28	49	Bhittamod-Jaleswor-Bardibas	281	Bhittamod, Jaleswor, Inaruwa, Bardibas
NH72	51	Dumkibas-Baguban Triveni	23	Dumkibas, Tribenidham
NH59	52	Murtihawa-Gulariya-Ramapur	154	Murtihawa, Gulariya, Rampur
NH51	54	Taulihawa-Gorusinge-Sandhikharka	83	Taulihawa, Gorusinge, Sandhikharka

Selected NHW	Ranking conducted by AHP	Junctions (Node)	Length (km)	Metro/Sub Metrocity/District HQ/Major Cities
NH32	59	Nawalpur-Malangawa-Sonbarsha	30	Nawalpur, Malangawa
NH54	65	Koilabas-Lamahi, Arjunkholagau-Ghorahi	211	Lamahi, Ghorahi
NH14	67	Kunauli-Rajbiraj	100	Kunauli, Rajbiraj
NH62	74	Khakraula-Tikapur-Muda	228	Khakraula, Tikapur, Muda
<b>Total</b>			<b>10410</b>	

Table 32: Selected Highways for III phase

Highway	Rank conducted by AHP	Names	Length Km
NH38	2	Kathmandu Outer Ringroad	68
NH21	4	Sitapaila-Dharke	24
NH33	20	Nijgadh-Kathmandu	76
NH46	23	Bhumahi-Parasi	9
NH25	24	Dumre-Beshisahar-Chame	108
NH48	27	Tansen-Ridi-Korla	254
NH30	31	Janakpur (Mujeliya) Dhanushadham-Dharapani Ramayan Circuit, Tarapatti-Pathara-Ma. Ra.Ma. - Pushpalpur	36
NH11	32	Phikkal-Shreeantu-Chabbise, Ilam	19
NH29	35	Kanchanban-Janaki Medical College-Mithileshwar Sabaila-Siraha-Naktajijh-Ramlaxman Chowk-Healthpost Mahendra Rajmarg	30
NH69	36	Jagat Bhanjyang-Mandalithan-Keware Bhanjyang-Barikuna-Kishan-Chapakot-Gajarkot Sadak, Syangja	42
NH76	38	Damak-Chisapani-Rabi	44
NH26	40	Jamunibas-Bateshwar-Shantipur-Kurtha-Janakpur	19
NH70	41	Seti Dovan-Wejang-Panchmul-Aaruchaur Ghante Deurali, Syangja	46
NH73	42	Surunga-Sharnamati-Tangandubba-Lasunganj, Jhapa	25
NH06	44	Chatara-Mulghat-Majhitar-Amarapurdanda-Ganeshchok (Tamor Corridor)	135

Highway	Rank conducted by AHP	Names	Length Km
NH74	47	Ilam (Biplate)-Maipokhari-Sandakpur, Ilam	50
NH68	48	Bhimad-Rampur-Mityal-Arung Khola	80
NH45	50	Khairenitar Bhimad Kawasoti	106
NH12	53	Ghurmi-Chatara Udayapur	163
NH07	55	Pakali-Naya Koshipul-Rupnagar, Pakali-Nadaha Koshipul Chatara	66
NH23	56	Diktel-Solu-Junbesi-Khahare-Jiribazar-Tamakoshi -Charikot-Khadichaur	291
NH60	57	Surkhet-Dailekh-Mahabulekh-Galje, Nagma-Gamgadhi-Nakchelagna	302
NH75	58	Sworna Sagarmatha Ringroad (Okhaldhunga-Solu-Salleri-Khotang-Diktel-Okhaldhunga)	135
NH71	60	Bhaluwang-Nuwakot-Khandaha-Kharwang	170
NH10	61	Deurali-Mudhe-Chainpur-Bohoratar	92
NH19	62	Ridi-Balkot-Hanshpur-Pyuthan, Pyuthan-Surkhet Road	220
NH57	63	Chinchu-Kudu-Jajarkot -Dunai-Dho-Tinje-Marim (Bheri Corridor)	317
NH43	64	Malekhu-Dhading-Salyantar	57
NH80	66	Mahendra Rajmarg Bastipurchase (Siraha)-B.P. Cancer Hospital-Belsot-Katari, Udayapur	30
NH31	68	Dolalghat-Chautara	25
NH79	69	Godar (Dhanusha) Chisapani-Mainawati-Kalapani-Dudhali, Sindhuli	20
NH56	70	Tharmare-Chaurjahari-Jajarkot Khalanga-Jumla Kudari-Mugu Rara (Rara Rajmarg)	263
NH49	71	Bartung Tansen Ridi Wamitaksar Kharwang	98
NH65	72	Khuttiya-Dipayal-Chainpur-Uraibhanjyang	296
NH67	73	Chandani-Bhimdatta-Bramhadev-Pancheshwar-Jhulaghat	201
NH53	75	Bhalubang Liwang Rolpa Madichaur Darbot	130
NH61	76	Surkhet Tallo Dundeshwor-Saatkhamba-Dullu-Pipalkot-Khulalu-Manma-Jumla Sadak	168
NH24	77	Lalgadh-Ranibas (R.T.O. Road)-Bishmat-Bahunmara-B.P. Rajmarg	29
NH63	78	Saphebagar-Martadi-Kolti	111
NH64	79	Khodpe-Chainpur (Bajhang)	108
NH27	80	Shitalpati Salyan Kubhinde Baluuwa Sangrahi	40
<b>Total</b>			<b>4503</b>

Note: The listed length is based on the length provided in the cabinet decision approved on 2076/02/06 BS (2019/09/19 AD)

## **4.5.2 LOCATION SELECTION FOR EVPCI**

### **4.5.2.1. GIS Mapping**

For the study, total 80 number of the national Highway with the length of 14913 km has been selected, where AHP and MCDM processes have been applied using GIS tool and experts' questionnaire survey for collecting criteria's significancy, which finally gave the output of the location of charging stations along this reach which is presented in the GIS Suitability Map.

This study identifies fifteen criteria for electric vehicle charging stations, including land slope, green area, land value, transportation hubs, petrol station, road network, income levels, population density, Junctions, distance to power cut area, electric vehicle ownership, water bodies, landslide risk zone, earthquake zone and existing EVCS. It provides detailed justifications for each criterion and its sub-criteria, and creates maps to display their spatial suitability. The sub-criteria scores are listed in table with walking distance between stations and demand points considered. The ideal distance is 500 meters.

#### **1. Green Area/ Vegetation**

This study will use green areas as an environmental factor to determine suitable locations for electric vehicle charging stations. A map layer is created using a remotely sensed image and the maximum likelihood supervised classification method on the Sentinel-2A satellite image, with locations further from green areas being more suitable. Green areas, including parks, forests, and vegetated spaces, are essential environmental factors in urban planning. When determining suitable locations for electric vehicle (EV) charging stations, it is crucial to consider their relationship with green spaces. This study uses green areas as a key criterion by analyzing remotely sensed satellite images to assess spatial suitability. The methodology involves creating a map layer using the maximum likelihood supervised classification method on a Sentinel-2A satellite image to distinguish vegetated areas. The study assumes that locations further from green areas are more suitable for EV charging infrastructure, as green areas are typically preserved for ecological and recreational purposes.

#### **Methodology: Remote Sensing and Classification**

To analyze green areas, Sentinel-2A satellite images are used due to their high-resolution multispectral data, which effectively differentiate vegetation from other land cover types. The maximum likelihood supervised classification (MLC) method is applied to categorize the land cover into different classes, including vegetation, water bodies, urban areas, and bare land.

#### **Satellite Data Collection**

Sentinel-2A images, captured by the European Space Agency (ESA), provide multi-band spectral data.

These images are processed to highlight vegetation using indices like the Normalized Difference Vegetation Index (NDVI), which helps separate green areas from non-vegetated surfaces

**Supervised Classification:** The maximum likelihood classifier (MLC) is used because it assumes a Gaussian distribution of pixel values and calculates the probability of each pixel belonging to a particular class. Training samples of known vegetation areas are selected, and the classifier assigns land cover labels to the entire image.

**Map Layer Creation:** After classification, a green area layer is generated. Using spatial analysis techniques in Geographic Information Systems (GIS), distance buffers are applied to determine how far potential charging station locations are from green areas.

### **Raster image resampling**

Raster image resampling involves changing the spatial resolution (cell size) of a raster dataset, either increasing (upsampling) or decreasing (downsampling) it, by interpolating new pixel values from existing ones. Resampling is the process of altering the spatial resolution of a raster dataset, meaning the size of each pixel (or cell) in the image. It's often necessary to resample rasters to a common resolution before combining or analyzing datasets with different resolutions.

**Reprojection:** When projecting an image to a different coordinate system, the pixel grid may no longer align with the original, requiring resampling to create a new image with a new grid.

**Analysis:** Resampling can be used to change the effective cell size of an existing dataset for specific analysis purposes.

**Common Resampling Methods:** Nearest Neighbor: This method assigns the value of the nearest pixel in the input raster to the corresponding pixel in the output raster. It's fast and preserves original pixel values, making it suitable for discrete data like land cover.

**Bilinear Interpolation:** This method calculates the value of each pixel in the output raster by averaging the values of the four surrounding pixels in the input raster, weighted by their distance. It's suitable for continuous data like temperature or elevation.

**Cubic Convolution:** This method calculates the value of each pixel in the output raster by fitting a smooth curve based on the surrounding 16 pixels. It produces a smoother image but can create values outside the range of the original data. Majority: This method determines the value of each pixel based on the most frequent value in a 4x4 window.

**Preservation of Natural Spaces:** Green areas are often designated for conservation, recreation, and biodiversity. Constructing charging stations near these areas could disrupt ecosystems and recreational activities.

**Urban Accessibility:** EV charging stations should be close to urban road networks and demand points rather than isolated green spaces. Placing them within built-up environments ensures higher usage rates and economic feasibility.

**Infrastructure Development Restrictions:** Many green areas have zoning regulations that prohibit large-scale infrastructure development. It is easier to integrate EV stations into commercial, residential, and transportation hubs rather than green zones.

**Minimizing Environmental Impact:** Green areas contribute to carbon sequestration and microclimate regulation. Placing charging stations in non-green areas reduces environmental disturbance.



**Figure 23 : Sentinel 2A images and land cover map**

Classification for parameter subclasses also identified iteratively classified fifteen sub-criteria for five classes (Saha & Roy, 2021).

**Table 33: Green area classification for AHP calculation and mapping**

Distance (m) from Green Area/ Vegetation (GV)	Rank	Class	Suitability
500	1	Very Low	Unsuitable
1000	2	Low	Low Suitable
1500	3	Moderate	Moderate Suitable
2000	4	High	Suitable
>2000	5	Very High	High Suitable

Summary of criteria, sub-criteria, suitability level, ranking of sub-criteria and weightage of criteria is shown below. Among all the mentioned sub criterion for Environmental/ Geographical factor, we took green area/vegetation for sub criterion. Green area/ vegetation was classified in to five classes. A conceptual representation of a green area suitability map, generated using Sentinel-2A satellite imagery and MLC classification is presented in Volume II. The map highlights: Green areas (parks, forests) marked in green. Urban areas where EV charging stations are more suitable. Distance buffers, showing that locations further from green spaces are preferred. By using remote sensing and GIS classification techniques, this study effectively identifies and maps green areas, ensuring that EV charging stations are placed in environmentally suitable locations. The approach balances urban development needs with ecological preservation, promoting sustainable mobility planning.

## 2. Land Slope

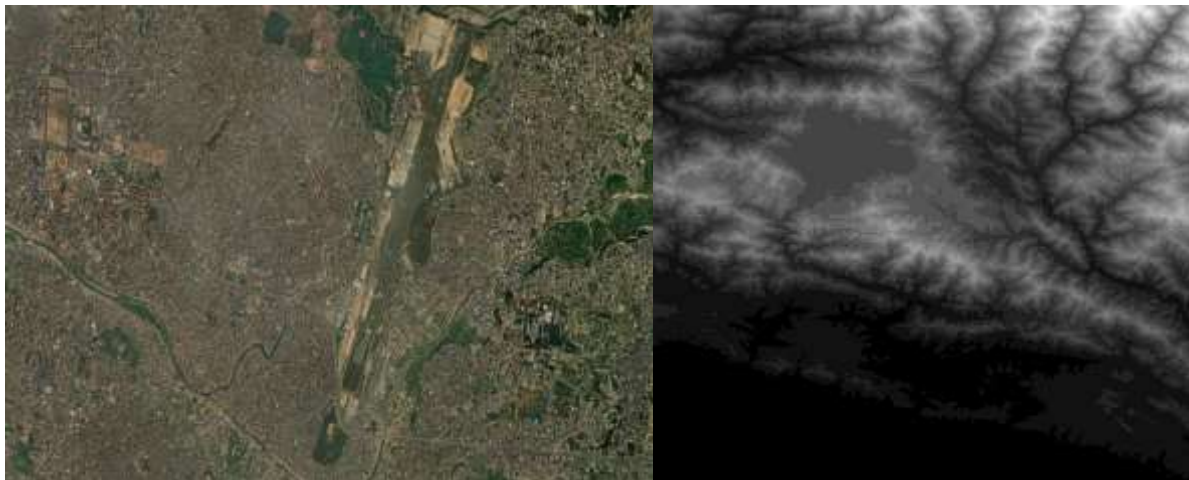
The process of choosing locations for electric vehicle charging stations can be impacted by slopes in terms of building costs and practicality. The places that have a high slope and are unstable are included in the study area. For these reasons, ArcMap's slope spatial analysis tool is used to build the slope map layer. As a source of data, the widely available SRTM digital elevation model is utilized. The place will be more appropriate if it has a modest slope.

Slope plays a crucial role in the selection of suitable locations for electric vehicle (EV) charging stations. The topography of an area directly affects construction costs, accessibility, safety, and long-term stability. Sites with steep slopes pose challenges due to increased earthwork costs, risk of erosion, and instability. In contrast, areas with a modest slope are preferred as they require less modification, making them more cost-effective and practical for charging station infrastructure.

To analyze terrain suitability, this study employs ArcMap's slope spatial analysis tool, which generates a slope map layer using data from the Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM). This method ensures an accurate assessment of slope variations within the study area, identifying optimal flat or gently sloping locations for EV charging stations.

**Methodology:** Slope Analysis Using GIS

Data Acquisition: A Digital Elevation Model (DEM) is a representation of the bare ground (bare earth) topographic surface of the Earth excluding trees, buildings, and any other surface objects. DEMs are created from a variety of sources. USGS DEMs used to be derived primarily from topographic maps. Those are being systematically replaced with DEMs derived from high-resolution lidar and IfSAR (Alaska only) data. SRTM 1 Arc-Second Global (Digital Object Identifier (DOI) number: /10.5066/F7PR7TFT) elevation data offer worldwide coverage of void filled data at a resolution of 1 arc-second (30 meters) and provide open distribution of this high-resolution global data set. Some tiles may still contain voids. Users should check the coverage map in Earth Explorer to verify if their area of interest is available. Please note that tiles above 50° North and below 50° South latitude are sampled at a resolution of 2 arc-second by 1 arc-second.



**Figure 24: Satellite image and SRTM DEM 1 Arc Second Global**  
(Source: <https://earthexplorer.usgs.gov/>)

The SRTM DEM is used as the primary data source. This digital elevation model provides a 30-meter resolution, making it suitable for detailed terrain analysis. Slope Calculation Using ArcMap Spatial Analyst tool in ArcMap is used to calculate the slope in degrees or percentage rise.

$$\text{Slope\_degrees} = \text{ATAN}(\sqrt{[\text{dz}/\text{dx}]^2 + [\text{dz}/\text{dy}]^2}) * 57.29578$$

The value 57.29578 shown here is a truncated version of the result from 180/pi.

a	b	c
d	e	f
g	h	i

The rate of change in the x direction for cell e is calculated with the following algorithm:

$$[dz/dx] = ((c + 2f + i) * 4/wght1 - (a + 2d + g) * 4/wght2) / (8 * x\_cellsize)$$

wght1 and wght2 are the horizontal weighted counts of valid cells.

The rate of change in the y direction for cell e is calculated with the following algorithm:

$$[dz/dy] = ((g + 2h + i) * 4/wght3 - (a + 2b + c) * 4/wght4) / (8 * y\_cellsize)$$

wght3 and wght4 are the same concept as in the [dz/dx] computation.

The tool classifies slope values, typically into flat (0–5°), gentle (5–10°), moderate (10–20°), and steep slopes (>20°).

**Map Layer Creation:** The generated slope layer helps identify suitable areas based on terrain steepness. Using GIS, areas with excessive slope (>15°) are excluded as unsuitable, while areas with gentle slopes (<10°) are prioritized. Rationale for Slope Consideration Construction and Maintenance Costs. Flat or gently sloping land reduces the need for earthwork, excavation, and retaining structures. Steep slopes require extensive grading and reinforcement, increasing installation costs.

**Stability and Safety:** Charging stations require firm ground for structural stability. Steep areas are prone to erosion, landslides, and water runoff, which may damage infrastructure over time.

**Accessibility for Vehicles:** EV charging stations should be easily accessible, ensuring that vehicles can enter, park, and charge conveniently. Steep terrain can create navigation challenges, especially in bad weather conditions.

**Energy Efficiency Considerations:** Vehicles require more energy to travel on steep slopes. Placing stations on moderate slopes can optimize energy consumption for vehicles traveling to and from the station.

**Urban and Transportation Planning:** Most urban and roadside locations are on relatively flat terrain, making integration with existing infrastructure easier. Steep areas may lack proper road connectivity and can be difficult to access, reducing user convenience.

Land slope is one of the prominent Environmental/Geographical factor. Classification for parameter for Land slope is presented in below Table.

**Table 34: Land slope classification for AHP calculation and mapping**

Land Slope (Degrees) LS	Rank	Class	Suitability
5	5	Very Low	High Suitable
10	4	Low	Suitable
15	3	Moderate	Moderate Suitable
20	2	High	Low Suitable
>20	1	Very High	Unsuitable

The map highlights: Flat and gentle slopes (shaded in green), indicating suitable areas for EV charging stations. Moderate slopes (yellow to orange), requiring assessment for feasibility. Steep and unstable slopes (red and black) which are unsuitable due to high construction costs and instability risks. Slope analysis is a critical factor in selecting locations for EV charging stations. By using GIS-based spatial analysis tools, areas with low to moderate slopes can be identified as optimal sites while steep and unstable areas are excluded. This method ensures that charging infrastructure is cost-effective, stable, accessible, and energy-efficient, supporting sustainable urban mobility. A conceptual representation of a land slope suitability map, generated using Sentinel-2A satellite imagery and MLC classification is presented in Volume II

### 3. Land values:

The economic factors that influence the appropriate placement of electric vehicle charging stations are determined by land values, as the research area encompasses locations with highly fluctuating land values. From this angle, the street-scaled figures in the NRs MOLCPA, are used to build the land values map layer. Each neighborhood's average land values are first determined, and these data are then linked to the appropriate spatial criterion layer. The location will be more appropriate if the land value is modest. Land Values and Their Influence on Electric Vehicle Charging Station Placement. Land values play a crucial role in determining the appropriate placement of electric vehicle (EV) charging stations. As urban areas experience fluctuations in land prices, these economic factors must be carefully considered when selecting optimal locations for EV infrastructure. The economic viability of EV charging stations depends on factors such as accessibility, demand, and cost-effectiveness. The research area in question includes locations with highly varying land values, making it essential to analyze the impact of these fluctuations on station placement.

**The Role of Land Values in EV Charging Station Placement:** In urban planning, land values are influenced by factors such as population density, commercial activity, proximity to transport hubs, and availability of amenities. High land values are typically found in central business districts (CBDs), while lower values are seen in suburban or less developed regions. The cost of acquiring or leasing land significantly impacts the feasibility of establishing EV charging stations. Since the goal is to provide accessible and affordable charging infrastructure, selecting locations with moderate to low land values can improve financial sustainability and encourage EV adoption.

**Utilizing the NRs MOLCPA for Land Value Analysis:** To ensure efficient allocation of charging stations, this study employs street-scaled figures from the NRs MOLCPA (National Regional Spatial Model for Land and Property Appraisal). This model provides insights into land value trends, helping planners create a comprehensive land values map layer. By integrating this data with spatial criteria, a systematic approach is adopted to determine suitable locations for EV charging stations. The first step in this process is calculating the average land values for each neighborhood. This involves aggregating data from property transactions, zoning regulations, and real estate trends. Once the average land values are established, they are linked to the spatial criterion layer, which considers factors such as road networks, traffic density, and urban development plans.

**Economic Viability and Land Value Considerations:** One of the key considerations when planning EV charging stations is the cost-benefit analysis. High land values often translate to increased operational expenses, potentially leading to higher charging fees for consumers. Conversely, areas with lower land values offer cost-effective solutions for infrastructure development. Selecting locations with moderate land prices ensures affordability while maintaining accessibility for a wide range of EV users.

For instance, placing charging stations in high-value commercial areas may attract more users but could also result in expensive leasing costs. On the other hand, suburban locations with lower land values may provide ample space for larger charging facilities but may require additional incentives to attract users. Balancing these factors is essential for an optimal EV infrastructure network. Land values are a critical determinant in the strategic placement of EV charging stations. By leveraging spatial analysis tools such as the NRs MOLCPA, planners can make data-driven decisions that optimize the economic feasibility of charging infrastructure. Prioritizing locations with moderate to low land values ensures a sustainable, cost-effective network while promoting widespread EV adoption. As the demand for EVs continues to grow, understanding the economic implications of land values will be instrumental in shaping the future of urban mobility.

### ख. काठमाडौं महानगरपालिका वडा नं. १३ अन्तर्गत निम्न सडकको दायँ बायाँको

सि.नं.	विवरण	प्रति आना रु.
१.	विष्णुमति खोला पुलदेखि रविभवन वडा नं. १४ को सिमानाम्म गणेशमान पथको	४१०००००।००
२.	कालिमाटी चोक देखी दक्षीण तर्फ कालीमाटी बल्खु (विश्वविद्यालय पथ) मुल सडक वडा नं. १४ को सिमाना सम्म	४१०००००।००
३.	टेकु कालिमाटी मुल सडकको विष्णुमति पुलदेखि उत्तरतर्फ नगर १५ को सिमानासम्मको मुल लिंक सडक	३१०००००।००
४.	कालीमाटी टंकेश्वर परोपकार विद्यालयको विष्णुमति पुल पश्चिम हुदै शिक्षा क्याम्पस ताहाचाल चोकबाट छाउनी म्युजियम हुदै सितापाईला रिडरोड चोक सम्मको मुल पक्की सडक	२६०००००।००
५.	सोल्तीमोड देखि हिमालय हाइट र छिन्नलता पुस्तकालयसम्मको पक्की सडक	२२०००००।००
६.	हिमालय हाइट वाफल कलंकी चक्रपथ हुदै का म न पा १३ को स्युचाटार सिमानासम्म ।	२२०००००।००
७.	गाइबाच्छा पाटी चोकबाट पश्चिम चक्रपथ सम्म पक्की सडक	२२०००००।००
८.	पक्की सडक	२२०००००।००
९.	कच्ची मोटर बाटो	१८०००००।००
१०.	गोरेटो बाटो	१२५००००।००
११.	बाटो नभएको	७२५०००।००

Loc Bodies	Rate
Kathmandu Mahanagarपालिका	155679.47
Lalitpur Mahanagarपालिका	117938.99
Bhaktapur Nagarpalika	110076.39
Suryabinayak Nagarpalika	110076.39
Bharatpur Mahanagarपालिका	90954.3
Madhyapur Thimi Nagarpalika	90419.89
Birendranagar Nagarpalika	90068.38
Pokhara Metropolitan City (Pokhara Lekhnath Mahanagarपालिका)	90000
Gokarneshwor Nagarpalika	72650.42
Birgunj Mahanagarपालिका	65262.66
Changunarayan Nagarpalika	64731.52
Mahalaxmi Nagarpalika	60000
Budhanilakantha Nagarpalika	58812.24
Chandragiri Nagarpalika	57082.47
Tarakeshwor Nagarpalika	56610.72
Itahari Upamahanagarपालिका	53155.11
Godawari Nagarpalika	53155.11
Molung Gaunपालिका	52581.2
Kirtipur Nagarpalika	51421.4

(Source: <https://dolma.gov.np/>)

**Figure 25: Land Values for mapping per square meter**

Classification for parameter for Land value is presented in below Table.

**Table 35: Land value classification for AHP calculation and mapping**

Land Values (NRS) LV	Rank	Class	Suitability
15000	1	Very Low	Unsuitable
30000	2	Low	Low Suitable
45000	3	Moderate	Moderate Suitable
60000	4	High	Suitable
>60000	5	Very High	High Suitable

The classification of land values serves as a critical parameter in evaluating site suitability for Electric Vehicle Charging Stations (EVCS). Very low land values (NRS 15,000) typically correspond to locations with limited accessibility and infrastructure, rendering them unsuitable for development. Sites with low land values (NRS 30,000) exhibit marginal demand potential and are thus considered low suitability. Moderate land values (NRS 45,000) strike a balance between acquisition cost and strategic location, qualifying these sites as moderately suitable. High land values (NRS 60,000) are indicative of well-connected, commercially vibrant areas, justifying their classification as suitable. Finally, very high land values (above NRS 60,000) represent prime urban or commercial zones with significant traffic and visibility, making them highly suitable despite elevated costs. This structured approach ensures that site selection optimizes both economic feasibility and operational effectiveness.

Land rate is included in to economic factor which is high in major metropolitan city, sub metro and municipality and low land value is obtained in hilly area and village council. A conceptual representation of a land value suitability map, generated using Sentinel-2A satellite imagery and MLC classification is presented in Volume II

### 3. Petrol stations

One of the first places that springs to mind for electric vehicle charging stations is the petrol stations. However, compared to electric vehicles, internal combustion engines have distinct station needs. Nonetheless, because these regions are situated in accordance with the current traffic network, the existing petrol stations might be thought of as appropriate sites for electric vehicle charging stations. It will be more appropriate if the location is close to petrol stations.

As the transition from internal combustion engine (ICE) vehicles to electric vehicles (EVs) gains momentum, one of the first locations that comes to mind for placing EV charging stations is petrol stations. Petrol stations are strategically positioned within the existing traffic network to provide convenient access to fuel for ICE vehicles, making them potentially suitable locations for EV charging infrastructure. However, despite their advantageous locations, petrol stations were originally designed to cater to the needs of gasoline and diesel-powered vehicles, which have different refueling requirements compared to EVs.

By leveraging the well-established locations of petrol stations, planners and policymakers can accelerate the expansion of EV charging infrastructure. Petrol stations are typically positioned

along major roads, highways, and in densely populated urban areas where vehicle traffic is high. This strategic placement ensures that EV drivers can access charging facilities without having to deviate significantly from their usual routes. Additionally, the existing amenities at petrol stations, such as convenience stores, restrooms, and food services, can enhance the overall charging experience for EV users, making the waiting time more convenient and productive.

### **Advantages of Locating EV Charging Stations at Petrol Stations**

**Strategic Traffic Network Placement:** Petrol stations are already positioned based on extensive research into traffic flow, vehicle density, and accessibility. Since these stations are designed to be easily reachable by motorists, they provide an excellent foundation for EV charging infrastructure. By utilizing these locations, EV users can benefit from the same level of convenience that ICE vehicle drivers currently experience.

**Availability of Space and Infrastructure:** Many petrol stations have open spaces, parking spots, and existing electrical connections that can be modified to accommodate EV chargers. Unlike setting up charging stations in completely new locations, retrofitting petrol stations for EV charging may reduce the costs associated with land acquisition and infrastructure development.

**Integration with Existing Services:** Petrol stations often feature additional amenities, such as cafes, restrooms, and retail stores. This makes them an ideal location for EV charging, as drivers typically need to spend 20 to 60 minutes at a charging station, depending on the charging speed and battery capacity. By providing a comfortable waiting environment, petrol stations can enhance the overall adoption of EVs.

**Encouraging the Transition from ICE Vehicles to EVs:** Placing EV chargers at petrol stations sends a strong message about the transition to sustainable transportation. ICE vehicle users who visit these locations will become more familiar with EV charging technology, potentially influencing their decision to switch to an electric vehicle in the future.

**Challenges and Considerations:** Despite their many advantages, integrating EV chargers into petrol stations also presents certain challenges:

**Power Supply Requirements:** Fast-charging stations require a significant electrical power supply, which may not be readily available at all petrol station locations. Upgrading the power grid infrastructure could be necessary to support high-power EV chargers.

**Space Constraints:** While some petrol stations have sufficient space to install EV chargers, others may be limited by their existing layout. In such cases, expansion or redesign may be required.

**Different Refueling Times:** Unlike petrol refueling, which takes only a few minutes, EV charging can take significantly longer. This requires designated parking spots for EVs, which may affect the overall flow of vehicles at the station.

The integration of EV charging stations at petrol stations is a practical and strategic approach to expanding EV infrastructure. These locations are already optimized for vehicle access, offer essential amenities, and can help bridge the gap between traditional fuel-based transportation and electric mobility. While challenges such as power supply and space constraints exist, the benefits of leveraging existing petrol stations far outweigh the drawbacks. By prioritizing the development of EV charging stations at these sites, governments and private stakeholders can accelerate the adoption of electric vehicles and contribute to a more sustainable transportation system. Classification for parameter for Urbanity Factor petrol station is presented in below Table.

**Table 36: Distance from petrol/ fuel station classification for AHP calculation and mapping**

Distance(m) from Petrol station PS	Rank	Class	Suitability
500	5	Very Low	High Suitable
1000	4	Low	Suitable
1500	3	Moderate	Moderate Suitable
2000	2	High	Low Suitable
>2000	1	Very High	Unsuitable

A conceptual representation of a petrol station suitability map, generated using Sentinel-2A satellite imagery and MLC classification is presented in Volume II-GIS Mapping

#### 4. Transportation Stations

Since the study area connects important portions of the city, it has a large number of public transport stations. Electric vehicle owners can take use of nearby transportation stations by parking their cars for charging while using public transit, which is a benefit of having electric vehicle charging stations nearby. Three million passengers use the metro and metro bus stations that make up the transportation map layer every day on average. It will be more appropriate if the location is close to transit hubs.

##### **The Importance of Transportation Stations for Electric Vehicle Charging Infrastructure**

As cities expand and transition toward sustainable transportation solutions, integrating electric vehicle (EV) charging stations into transportation hubs has become a strategic necessity. Transportation stations such as metro, metro bus, and train stations serve as major connection points for millions of commuters daily. These stations offer an excellent opportunity to install EV charging infrastructure, providing a convenient solution for EV owners who rely on public transit.

In the study area, where various parts of the city are well-connected, the presence of a large number of public transport stations further enhances the potential for EV charging stations. The integration of EV charging stations within transportation hubs offers multiple benefits, including improved convenience for EV users, better land use, reduced range anxiety, and the promotion of multimodal transportation.

**Enhancing Convenience for Electric Vehicle Owners:** One of the key advantages of placing EV charging stations near transportation hubs is the added convenience for EV owners. Many individuals who commute daily prefer to park their vehicles near metro or bus stations and continue their journey using public transport. By installing EV chargers in these locations, commuters can charge their vehicles while they are away, reducing downtime and making their travel more efficient.

For instance, an EV owner can park their car at a metro station in the morning, take the metro to work, and return in the evening to a fully charged vehicle. This setup eliminates the need for separate charging stops, making EV ownership more practical and hassle-free. The ability to charge while using public transit aligns with the goal of maximizing efficiency and reducing the time required for vehicle refueling.

**Better Land Utilization and Reduced Congestion:** Urban areas often struggle with space constraints, making efficient land use crucial. Parking facilities at metro and bus stations are already designated for commuter use, which presents an opportunity to integrate EV charging stations without requiring additional land acquisition. By leveraging existing parking lots, cities can optimize land use while encouraging sustainable transportation.

Furthermore, placing EV charging stations at transit hubs helps reduce overall road congestion. Many EV owners will opt for public transport for longer city commutes, leaving their cars parked and charging instead of contributing to traffic. This shift can lower the number of private vehicles on roads during peak hours, leading to a reduction in congestion and associated air pollution.

**Addressing Range Anxiety and Encouraging EV Adoption:** One of the major concerns for prospective EV buyers is range anxiety the fear of running out of charge before reaching a charging station. By installing charging stations at key transportation hubs, cities can create a reliable and accessible charging network. Commuters who rely on public transport will have the assurance that their vehicle is charging while they travel, eliminating the stress of searching for charging points later.

Additionally, the presence of charging infrastructure at transportation hubs can serve as a catalyst for greater EV adoption. Potential EV buyers are more likely to make the switch when they see convenient and widely available charging options integrated into their daily routine. This aligns with broader sustainability goals by promoting cleaner energy use and reducing reliance on fossil fuel-powered vehicles.

**Supporting Sustainable and Multimodal Transportation:** Integrating EV charging infrastructure with transit hubs promotes multimodal transportation a system where individuals use a combination of travel modes for their daily commute. This synergy between electric vehicles and public transit creates a seamless transportation network that reduces carbon emissions and enhances overall mobility.

Governments and urban planners are increasingly recognizing the role of multimodal transportation in sustainable city development. By investing in EV charging stations at metro and bus stations, cities can create a more resilient and environmentally friendly transportation

ecosystem. This approach supports global sustainability efforts and contributes to achieving climate change mitigation goals.

The presence of a large number of public transport stations in the study area presents a unique opportunity for integrating EV charging infrastructure. By placing charging stations near metro and metro bus stations, cities can offer convenience to EV owners, optimize land use, reduce congestion, and encourage greater EV adoption. Additionally, this approach supports sustainable and multimodal transportation, creating a greener and more efficient urban mobility system. As electric vehicles continue to grow in popularity, well-planned charging infrastructure at transportation hubs will play a critical role in ensuring the success of this transition.

Classification for parameter for Urbanity Factor transportation station is presented in below Table.

**Table 37: Distance from transportation station classification for AHP calculation and mapping**

Distance(m) from Transportation Station TS	Rank	Class	Suitability
500	5	Very Low	High Suitable
1000	4	Low	Suitable
1500	3	Moderate	Moderate Suitable
2000	2	High	Low Suitable
>2000	1	Very High	Unsuitable

## 5. Income Rate

When choosing a location for an electric vehicle charging station, income rates can be taken into consideration. The publically available income rate figures for the districts are used to build the map layer. There are three ranges assigned to this new map layer. The place will be more appropriate if the income rate is high.

Income rate is an important factor when selecting the ideal location for an electric vehicle (EV) charging station. Higher-income areas often have greater EV adoption rates, making them more suitable for charging infrastructure development. Publicly available income rate data for districts can be used to build a map layer that categorizes different regions based on their economic standing. In this study, income rates are divided into three ranges, allowing for a more strategic approach to site selection. The general principle is that locations with higher income rates are more appropriate for installing EV charging stations due to their potential for higher usage and return on investment.

**Correlation Between Income and Electric Vehicle Adoption:** Higher-income areas tend to have a higher concentration of electric vehicles. This trend is largely due to the fact that EVs, despite becoming more affordable, still require a significant upfront investment compared to traditional gasoline-powered vehicles. Additionally, many high-income households have access to home charging solutions, which means they are more likely to own an EV. When planning charging station locations, it is beneficial to target areas where residents can afford

EVs and are more likely to use public charging infrastructure. In districts with high-income rates, the demand for public charging stations can be substantial, particularly for apartment dwellers who may not have private charging facilities. Moreover, these areas often have commercial centers, offices, and entertainment venues that attract EV owners, further increasing the demand for charging stations.

**The Three Income Ranges and Their Suitability:** The study categorizes the income rates of different districts into three distinct ranges:

**High-Income Areas** – These areas have the highest potential for EV charging station deployment. Residents in these regions are more likely to own electric vehicles and are willing to pay for premium fast-charging services. Additionally, businesses in these areas may be interested in installing charging stations to attract eco-conscious customers. High-end shopping malls, corporate offices, and residential complexes in these districts can benefit from strategically placed EV charging stations.

**Middle-Income Areas** – These districts present a moderate opportunity for EV charging infrastructure. While EV ownership may not be as widespread as in high-income areas, there is still a growing market for electric vehicles. Government incentives and falling EV prices are making electric cars more accessible to the middle class. Public charging stations in these areas can serve both current EV owners and those considering switching to electric vehicles.

**Low-Income Areas** – These locations may have lower priority for EV charging stations due to a smaller number of EV owners. However, they should not be entirely excluded from charging infrastructure planning. Public transport electrification, ridesharing programs, and government-supported initiatives can still drive demand for charging stations in these areas. Additionally, as EV prices decrease over time, adoption in lower-income areas is expected to rise, making future-proofing these locations a strategic consideration.

### **Economic Benefits of Installing Charging Stations in High-Income Areas**

Choosing high-income areas for charging station deployment not only ensures demand but also improves financial viability. Operators of EV charging stations need a return on their investment, which is more likely when stations are placed in areas with a high concentration of EV users. These locations often support premium charging services, such as fast-charging networks, which generate higher revenue. Furthermore, businesses and commercial centers in high-income districts may be willing to partner with EV charging providers to offer incentives for customers. This collaboration can help create a sustainable revenue model for charging station operators while benefiting businesses by attracting environmentally conscious consumers.

### **Future Considerations and Equitable Charging Infrastructure**

While high-income areas are prime locations for EV charging stations, it is crucial to consider equitable access to charging infrastructure across all income levels. Government incentives and subsidies can help bridge the gap by encouraging charging station installations in middle- and low-income areas. Additionally, expanding public charging networks in diverse economic regions supports the long-term goal of making EV adoption more inclusive. Income rate is a

key factor in determining the most appropriate locations for EV charging stations. Higher-income districts tend to have more EV owners, ensuring greater utilization of charging infrastructure and making these areas more financially viable for charging station deployment. By using income rate data to build a map layer, urban planners and businesses can strategically place charging stations in areas where they are most needed and profitable. However, future planning should also include efforts to expand charging infrastructure to middle- and low-income areas to support the broader transition to electric mobility.

Classification for parameter for Economic Factor Income rate is presented in below Table.

**Table 38: Income rate classification for AHP calculation and mapping**

Income Rate (NRS) IR	Rank	Class	Suitability
75000	1	Very Low	Unsuitable
150000	2	Low	Low Suitable
225000	3	Moderate	Moderate Suitable
300000	4	High	Suitable
>300000	5	Very High	High Suitable

## 6. Road Network

The highways that electric vehicles frequently travel on are essential for figuring out where electric vehicle charging stations should be placed. Roads with two or more lanes are identified in order to generate the roads map layer, and the new map layer is then created utilizing this data. A vector data format is used to construct the road map layer. The location will be more appropriate if it is close to the roads. The road network plays a crucial role in determining optimal locations for EVCSs. Highways and major roads serve as primary transportation routes for electric vehicle (EV) users, making them essential factors in planning charging infrastructure. Roads with two or more lanes are identified to generate a comprehensive road map layer using vector data format. Highway selection was conducted by an expert team which is presented in Annex-V. Total 14913 Km length of 80 national highways were selected by AHP techniques with different criteria like: Traffic flow, AADT, importance of road, geometry etc.

One of the key considerations when placing EVCSs is their proximity to roads that experience frequent EV traffic. Highways and roads with two or more lanes typically accommodate a significant volume of vehicles, making them ideal locations for charging stations. The rationale behind this approach includes:

**Increased Accessibility:** EV users frequently travel along major highways and roads, making it essential to provide charging stations at convenient locations. Placing EVCSs near these roads ensures that drivers can access charging points without deviating significantly from their routes.

**Support for Long-Distance Travel:** Highways facilitate long-distance travel, where drivers require strategically placed charging stations to complete their journeys. Fast-charging stations

along highways help mitigate range anxiety, enabling EV owners to confidently undertake longer trips.

**Efficient Use of Infrastructure:** Existing road networks offer infrastructure such as rest stops, fuel stations, and commercial centers, making them ideal for co-locating EV charging facilities. Integrating charging stations into these established hubs optimizes land use and enhances user convenience.

**Encouraging EV Adoption:** The visibility of EV charging stations along major roads reassures potential EV buyers that adequate charging infrastructure is available, encouraging greater adoption of electric mobility.

**Creating a Road Network Map for EVCS Placement:** To determine suitable locations for EVCSs, a road map layer is created using vector data format. This mapping process involves the following steps:

- **Identifying Major Roads and Highways:** The first step in creating the road network map is identifying major highways, expressways, and roads with two or more lanes. Data is collected from geographic information system (GIS) sources, transportation departments, and mapping services to outline the most traveled routes
- **Generating the Road Map Layer:** A vector data format is used to construct the road map layer. Vector data allows for precise representation of roads, ensuring accurate mapping of charging station locations. The map layer classifies roads based on their type, traffic volume, and importance in regional transportation.
- **Analyzing Road Density and Traffic Flow:** Roads are categorized based on vehicle traffic density to determine the highest-priority locations for EVCS placement. Areas with high EV traffic are marked for potential charging station installations.
- **Evaluating Existing Infrastructure:** The proximity of rest stops, commercial centers, parking areas, and public facilities is assessed to determine feasible locations for installing charging stations. Factors such as road width, accessibility, and connection to the power grid are considered.

### Benefits of Placing EVCSs near Road Networks

- **Reduced Charging Time and Improved Efficiency:** Strategic placement of EVCSs along highways and major roads allows for fast charging solutions, reducing downtime for EV users. Fast chargers positioned at key locations enable drivers to continue their journey with minimal delay.
- **Enhanced Convenience for EV Users:** Drivers often plan their routes based on the availability of charging infrastructure. By placing EVCSs near major roads, cities can improve route planning options for EV users, ensuring they have access to charging points when needed.
- **Economic Benefits and Commercial Growth:** Establishing charging stations along roads enhances business opportunities for commercial centers, gas stations, and rest stops. EVCSs attract customers who may utilize nearby amenities while waiting for their vehicles to charge, boosting local businesses.

- **Environmental and Sustainability Advantages:** An extensive network of charging stations along roadways encourages more drivers to switch to electric vehicles, reducing overall carbon emissions. Well-planned charging infrastructure supports the transition to a cleaner and more sustainable transportation system.
- **Challenges and Considerations:** While road networks offer prime locations for EVCS placement, certain challenges must be addressed:
- **Land Availability:** Securing space for charging stations along busy roads may require negotiations with local authorities or private landowners.
- **Power Supply and Grid Stability:** Charging stations need a stable power supply, requiring careful planning to avoid overloading the electrical grid.
- **Weather Conditions:** Some highways and roads may experience extreme weather conditions, impacting the efficiency and durability of EVCSs.
- **Traffic Management:** High-traffic areas may require dedicated EV charging lanes or parking spaces to prevent congestion and ensure smooth operations.

The road network plays a crucial role in the strategic placement of EVCSs, ensuring accessibility, efficiency, and convenience for electric vehicle users. Highways and multi-lane roads are prime locations for charging stations, supporting both urban commuters and long-distance travelers. By creating a road map layer using vector data and analyzing traffic density, planners can identify the most suitable locations for EV charging infrastructure. Investing in a well-connected charging network along major roads will accelerate EV adoption, enhance the driving experience, and contribute to sustainable urban mobility.

Classification for parameter for Urbanity Factor distance from road is presented in below Table

**Table 39: Distance from road classification for AHP calculation and mapping**

Distance (m) from Road Network RN	Rank	Class	Suitability
500	5	Very Low	High Suitable
1000	4	Low	Suitable
1500	3	Moderate	Moderate Suitable
2000	2	High	Low Suitable
>2000	1	Very High	Unsuitable

## 7. Population density

Where electric vehicles are often utilised, there is a greater need for charging facilities. Because of this, one criterion that can be used to identify these locations is population density. CBS most recent population data is used in this investigation. After calculating the population density in each neighbourhood, the neighbourhoods are categorized using the Natural Breaks (Jenks) approach. A high population density will make the location more appropriate. As the adoption of electric vehicles (EVs) continues to rise, ensuring the availability of adequate charging infrastructure becomes a critical component of sustainable urban planning. One of the most significant factors influencing the placement of EV charging stations is population

density. Areas with higher population densities tend to have more vehicle usage, making them prime locations for charging stations. This analysis leverages the most recent population data from the Central Bureau of Statistics (CBS) to determine the most suitable neighborhoods for EV charging facilities.

**Importance of Population Density in EV Charging Infrastructure:** Population density is a key determinant in the demand for various public services, including transportation infrastructure. In densely populated areas, there is typically a greater reliance on shared and public transportation, as well as a higher number of vehicles per unit area. This increased demand extends to EVs and their associated charging infrastructure. Electric vehicles are more common in urban settings where short commutes, environmental concerns, and government incentives encourage their adoption. Consequently, densely populated neighborhoods require more charging stations to accommodate the rising number of EV users. This ensures that residents have easy access to charging points, reducing range anxiety and promoting the transition from traditional combustion-engine vehicles to EVs.

**Data Utilization and Calculation of Population Density:** To determine the most suitable locations for EV charging stations, the CBS's most recent population data is used. Population density is calculated using the standard formula: By applying this formula to each neighborhood, we obtain a quantitative measure of population concentration. High-density areas are those with a larger number of people per square kilometer, signifying a greater likelihood of EV usage and thus a higher demand for charging infrastructure.

**Categorization Using the Natural Breaks (Jenks) Method:** Once population density is calculated for all neighborhoods, categorization is necessary to identify the most strategic locations for EV charging stations. The Natural Breaks (Jenks) method is employed to classify neighborhoods based on population density.

The Jenks optimization method is a clustering algorithm designed to reduce variance within groups while maximizing variance between groups. This approach identifies natural groupings within the data, segmenting neighborhoods into categories such as low, medium, and high population density. High-density areas emerge as prime candidates for EV charging infrastructure due to their greater likelihood of EV adoption and higher demand for public charging facilities.

**Suitability of High-Population-Density Locations:** Neighborhoods classified in the highest population density category are considered the most appropriate for the installation of EV charging stations. These areas typically exhibit:

- **Higher EV adoption rates:** More residents are likely to own or consider purchasing an EV.
- **Limited private charging options:** Apartment buildings and high-rise residential complexes often lack private garages or dedicated parking spaces with charging capabilities.
- **Increased vehicle turnover:** A greater number of vehicles in a given area results in frequent demand for charging stations.

- **Stronger public infrastructure support:** Municipal planning in high-density areas often prioritizes sustainable transportation solutions. By focusing on these high-density neighborhoods, city planners and policymakers can ensure efficient distribution of charging infrastructure, meeting the growing needs of urban EV users.

Population density plays a crucial role in determining the suitability of locations for EV charging stations. Utilizing the CBS's latest population data and employing the Natural Breaks (Jenks) method allows for a data-driven approach in identifying high-density neighborhoods where charging infrastructure is most needed. Implementing EV charging facilities in these areas not only supports current EV owners but also encourages further adoption of electric vehicles, contributing to a more sustainable urban environment.

Classification for parameter for Urbanity Factor Service area population is presented in below Table.

**Table 40: Population density classification for AHP calculation and mapping**

Population Density(/Sq.km) PD	Rank	Class	Suitability
200	1	Very Low	Unsuitable
400	2	Low	Low Suitable
600	3	Moderate	Moderate Suitable
800	4	High	Suitable
>800	5	Very High	High Suitable

## 8. Junctions

In order to maximize the number of cars that reach the service, the EVCSs should be located near intersections. Electric Vehicle Charging Stations (EVCSs) are a critical component of the growing electric vehicle (EV) infrastructure, and their strategic placement can significantly impact the efficiency and accessibility of charging services for EV owners. One of the most effective strategies for maximizing the number of cars that can reach and utilize these stations is to locate them near intersections or junctions. This approach offers several advantages, including increased visibility, convenience, and accessibility, which collectively contribute to a more robust and user-friendly charging network.

- **Increased Visibility and Accessibility:** Intersections are naturally high-traffic areas where multiple roads converge, making them prime locations for EVCSs. Placing charging stations near junctions ensures that they are easily visible to a large number of drivers, including those who may not be actively searching for a charging point but could benefit from one during their journey. This visibility is crucial for encouraging spontaneous use, especially for drivers who may be running low on battery and need a quick charging solution. Additionally, intersections are often well-marked and easily identifiable, reducing the likelihood of drivers missing the charging station.
- **Convenience for Drivers:** Locating EVCSs near intersections provides unparalleled convenience for EV owners. Intersections are typically points where drivers make decisions about their route, such as turning onto a different road or continuing straight.

By placing charging stations at these decision points, drivers can easily incorporate charging into their journey without significant detours. This is particularly beneficial for urban areas where traffic congestion and limited parking spaces can make it challenging to find and access charging stations. Furthermore, intersections often have existing infrastructure, such as parking lots or service stations, which can be leveraged to accommodate EVCSs without the need for extensive new construction.

- **Optimizing Traffic Flow:** Placing EVCSs near intersections can also help optimize traffic flow and reduce congestion. Drivers can charge their vehicles while waiting at traffic lights or during brief stops, minimizing the time spent idling and reducing the overall carbon footprint of the transportation network. Additionally, strategically located charging stations can help distribute the load across multiple intersections, preventing overcrowding at a single location and ensuring a more even distribution of charging demand.
- **Integration with Public Transportation Hubs:** Many intersections are also hubs for public transportation, such as bus stops, tram lines, or train stations. By locating EVCSs near these hubs, cities can create a seamless multimodal transportation network that encourages the use of both public transit and electric vehicles. This integration can be particularly beneficial for commuters who may need to charge their EVs while using public transportation for part of their journey. It also supports the concept of "park and charge," where drivers can leave their vehicles at a charging station while continuing their trip via public transit.
- **Economic and Environmental Benefits:** From an economic perspective, placing EVCSs near intersections can drive higher utilization rates, making the stations more profitable for operators. Higher utilization also means that the infrastructure investment is more quickly recouped, encouraging further expansion of the charging network. Environmentally, the increased accessibility and convenience of well-placed EVCSs can accelerate the adoption of electric vehicles, reducing greenhouse gas emissions and improving air quality in urban areas.

In conclusion, locating EVCSs near intersections is a strategic approach that maximizes the number of cars that can access and benefit from charging services. By enhancing visibility, convenience, and accessibility, this placement strategy not only supports the growing number of EV owners but also contributes to the broader goals of reducing traffic congestion, integrating multimodal transportation networks, and promoting sustainable urban development. As the adoption of electric vehicles continues to rise, the thoughtful placement of charging infrastructure will be key to ensuring a smooth and efficient transition to a cleaner, greener transportation future.

Classification for parameter for Urbanity Factor Proximity to Junctions is presented in below Table.

**Table 41: Proximity to Junctions classification for AHP calculation and mapping**

Distance (m) from Junctions/ Nodes JN	Rank	Class	Suitability
500	5	Very Low	High Suitable
1000	4	Low	Suitable

Distance (m) from Junctions/ Nodes JN	Rank	Class	Suitability
1500	3	Moderate	Moderate Suitable
2000	2	High	Low Suitable
>2000	1	Very High	Unsuitable

## 9. Power Availability area

The EVCSs should be built in locations far from frequent power outages. In Nepal, where the electric vehicle (EV) market is gradually gaining traction, the strategic placement of Electric Vehicle Charging Stations (EVCSs) is crucial for ensuring reliability and user satisfaction. One of the most significant challenges in this context is the frequent power outages, commonly referred to as load shedding, which have historically plagued the country. To ensure the effectiveness and reliability of EVCSs, it is essential to locate them in areas with stable electricity supply, far from regions prone to frequent power cuts. Municipal-level data can play a pivotal role in identifying such areas, ensuring that EVCSs are built in locations where they can operate consistently and meet the needs of EV users.

- Understanding Nepal's Power Supply Challenges:** Nepal's electricity infrastructure has faced significant challenges, including insufficient generation capacity, transmission losses, and an uneven distribution of power supply. While hydropower has been a major focus for electricity generation, seasonal variations in water flow and inadequate infrastructure have led to frequent power outages, particularly in rural and semi-urban areas. Urban centers, especially in the Kathmandu Valley, have relatively better power supply due to prioritized distribution, but even these areas are not entirely immune to outages. Therefore, identifying regions with stable power supply is critical for the successful deployment of EVCSs.
- Leveraging Municipal-Level Data:** Municipal-level data on electricity supply and outage frequency can provide valuable insights for determining the optimal locations for EVCSs. By analyzing this data, stakeholders can identify municipalities with reliable power infrastructure and minimal load shedding. For instance, municipalities with access to dedicated hydropower plants, substations, or backup power systems are likely to have more stable electricity supply. Additionally, areas with planned infrastructure upgrades or those connected to the national grid through robust transmission lines should be prioritized for EVCS deployment.
- Prioritizing Urban and Industrial Hubs:** Urban centers and industrial hubs are often better equipped with reliable power infrastructure compared to rural areas. Cities like Kathmandu, Pokhara, and Biratnagar have relatively stable electricity supply due to their economic importance and higher investment in infrastructure. These areas also have higher concentrations of EV users, making them ideal locations for EVCSs. Furthermore, industrial zones and commercial districts within these municipalities often have backup power systems, such as generators or solar installations, which can further ensure uninterrupted charging services.
- Incorporating Renewable Energy Solutions:** In regions where power outages are frequent, integrating renewable energy solutions, such as solar or battery storage

systems, can enhance the reliability of EVCSs. Municipalities with high solar potential, such as those in the Terai region or areas with ample sunlight, can leverage solar-powered charging stations to mitigate the impact of power cuts. Battery storage systems can also provide backup power during outages, ensuring continuous operation of the charging stations.

- **Collaboration with Local Authorities and Utilities:** Effective collaboration with local municipalities and electricity utilities is essential for identifying stable power supply areas and ensuring the successful deployment of EVCSs. Municipalities can provide data on power outage frequency, infrastructure plans, and zoning regulations, while utilities can offer insights into grid stability and future upgrades. Public-private partnerships can also play a key role in funding and implementing EVCS projects in areas with reliable power supply.
- **Economic and Environmental Benefits:** Locating EVCSs in areas with stable power supply not only ensures reliability but also enhances user confidence in the EV ecosystem. Reliable charging infrastructure can accelerate EV adoption, reducing dependence on fossil fuels and contributing to Nepal's climate goals. Additionally, stable power supply reduces operational costs for EVCS operators, as they can avoid the expenses associated with frequent downtime or backup power solutions.

In Nepal, where power outages remain a significant challenge, the strategic placement of EVCSs in areas with stable electricity supply is critical for building a reliable and efficient charging network. By leveraging municipal-level data, prioritizing urban and industrial hubs, and incorporating renewable energy solutions, stakeholders can ensure that EVCSs are built in locations far from frequent power cuts. This approach not only enhances the user experience but also supports the broader goals of promoting sustainable transportation and reducing greenhouse gas emissions in Nepal.

Classification for parameter for Economic Factor power cut area is presented in below Table.

**Table 42: PowerAvailability area classification for AHP calculation and mapping**

Power Availability Area (%) PA	Rank	Class	Suitability
15	1	Very Low	Unsuitable
30	2	Low	Low Suitable
45	3	Moderate	Moderate Suitable
60	4	High	Suitable
>60	5	Very High	High Suitable

## 10. Electric vehicle ownership in the service area

A high ownership percentage of electric vehicles is necessary to enable many owners to utilize charging services. The success of Electric Vehicle Charging Stations (EVCSs) in Nepal is intrinsically linked to the percentage of electric vehicle (EV) ownership in the service area. A high ownership rate of EVs is essential to ensure the utilization and financial viability of

charging infrastructure. Without a sufficient number of EVs on the road, charging stations risk underutilization, leading to economic losses and hindering the growth of the EV ecosystem. Therefore, fostering EV adoption and ensuring a high ownership percentage in service areas is critical for the sustainable development of EVCSs across Nepal.

- **Current State of EV Ownership in Nepal:** Nepal has seen a gradual increase in EV adoption in recent years, driven by rising fuel costs, environmental awareness, and government incentives. Electric two-wheelers, such as scooters and motorcycles, dominate the EV market due to their affordability and suitability for urban commuting. However, the adoption of electric cars and buses remains relatively low, primarily due to higher upfront costs and limited charging infrastructure. Despite these challenges, cities like Kathmandu, Pokhara, and Lalitpur have witnessed a growing number of EVs, indicating a positive trend that can be leveraged to expand EVCS networks.
- **Importance of High EV Ownership for Charging Infrastructure:** A high percentage of EV ownership in a service area directly correlates with the demand for charging services. When more EVs are on the road, the need for accessible and reliable charging stations increases, ensuring higher utilization rates. This, in turn, makes EVCSs economically viable for operators and encourages further investment in charging infrastructure. Conversely, low EV ownership can lead to underutilized stations, making it difficult for operators to recover costs and discouraging future expansion.

**Strategies to Boost EV Ownership:** To achieve a high percentage of EV ownership, several strategies can be implemented at the national, municipal, and community levels:

- **Government Incentives and Policies:** The Nepalese government can play a pivotal role in promoting EV adoption through targeted policies and incentives. These may include tax exemptions, subsidies on EV purchases, reduced import duties on EVs and charging equipment, and lower registration fees for electric vehicles. Additionally, policies that prioritize EVs in public procurement, such as electric buses for public transportation, can set an example and encourage private adoption.
- **Awareness Campaigns and Education:** Public awareness campaigns can help dispel misconceptions about EVs, such as range anxiety and high maintenance costs. Educating consumers about the long-term economic and environmental benefits of EVs can drive adoption. Collaborations with schools, colleges, and community organizations can further amplify these efforts.
- **Expansion of Charging Infrastructure:** The availability of reliable and accessible charging infrastructure is a key driver of EV adoption. By strategically deploying EVCSs in high-traffic areas, urban centers, and along major highways, the government and private sector can address range anxiety and make EVs a more practical choice for consumers.
- **Partnerships with Financial Institutions:** Affordable financing options, such as low-interest loans or lease-to-own schemes for EVs, can make them more accessible to a

broader segment of the population. Partnerships with banks and microfinance institutions can facilitate these initiatives.

**Targeting High-Potential Service Areas:** To maximize the impact of EVCSs, it is essential to focus on service areas with high potential for EV adoption. Urban centers, where traffic congestion and air pollution are significant concerns, are ideal targets for promoting EVs. Additionally, areas with higher disposable incomes and a culture of environmental consciousness are more likely to embrace electric vehicles. Municipal-level data can help identify these high-potential areas and guide the deployment of charging infrastructure.

**Economic and Environmental Benefits:** A high percentage of EV ownership not only supports the growth of charging infrastructure but also contributes to broader economic and environmental goals. Increased EV adoption reduces dependence on imported fossil fuels, improving energy security and saving foreign exchange. Environmentally, the shift to electric vehicles can significantly reduce greenhouse gas emissions and air pollution, contributing to Nepal's climate commitments and improving public health.

In conclusion, a high percentage of electric vehicle ownership in service areas is essential for the successful deployment and utilization of EVCSs in Nepal. By implementing targeted policies, raising awareness, expanding charging infrastructure, and focusing on high-potential areas, stakeholders can drive EV adoption and create a sustainable ecosystem for electric mobility. As EV ownership grows, the demand for charging services will increase, ensuring the economic viability of EVCSs and paving the way for a cleaner, greener future for Nepal. Passenger car unit is calculated from empirical formula (Minocha, 2004).

Vehicle type	Relation between passenger car unit and carriageway width (w)	$R^2$ value
Bus	$PCU^b = 0.1114w + 3.073$	0.92
Truck	$PCU = 0.146w + 4.40$	0.95
LCV	$PCU = 0.097w + 1.956$	0.99
Tractor Trailer	$PCU = 0.103w + 4.95$	0.99
Three-Wheeler	$PCU = 0.168w + 0.327$	0.95
Two-Wheeler	$PCU = 0.017w + 0.158$	0.97
Cycle	$PCU = 0.034w + 0.225$	0.99
Rickshaw	$PCU = 0.054w + 1.132$	0.97

<sup>a</sup>LCV indicates light commercial vehicle.

<sup>b</sup>PCU indicates passenger car unit.

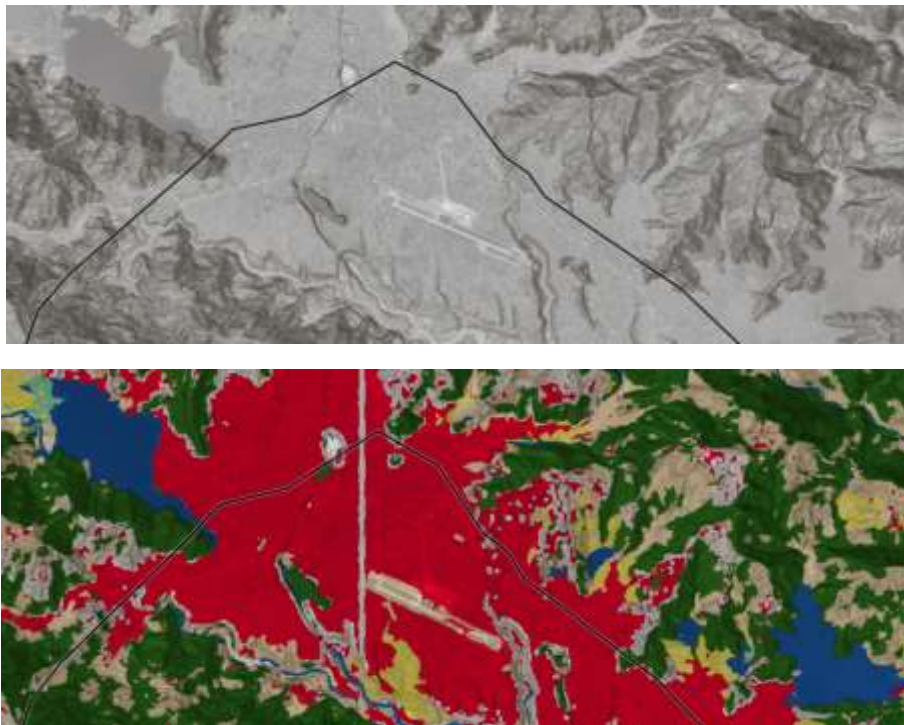
Classification for parameter for Economic Factor Electric Vehicle ownership in the service area is presented in below Table.

**Table 43: Electric Vehicle ownership in the service area classification for AHP calculation and mapping**

Electric Vehicle Ownership (PCU) in the Service Area (EVO)	Rank	Class	Suitability
500	1	Very Low	Unsuitable
1000	2	Low	Low Suitable
1500	3	Moderate	Moderate Suitable
2000	4	High	Suitable
>2000	5	Very High	High Suitable

## 11. Proximity of water bodies

EVCSs should be erected far from water sources because their construction may have an adverse effect on urban water sources, such as green spaces. The construction and operation of Electric Vehicle Charging Stations (EVCSs) in Nepal must be carefully planned to minimize their environmental impact, particularly on urban water sources and green spaces. Nepal, a country rich in water resources, is home to numerous rivers, lakes, wetlands, and other water bodies that are vital for ecosystems, agriculture, and human livelihoods. Proximity to these water bodies during the construction of EVCSs can pose significant environmental risks, including pollution, habitat disruption, and degradation of water quality. By leveraging global landcover maps to identify and analyze water bodies in Nepal, stakeholders can ensure that EVCSs are erected at a safe distance, preserving the integrity of these critical natural resources while supporting the growth of sustainable transportation infrastructure.



**Figure 26: Satellite imagery and land cover map covering water bodies**

- **Environmental Risks of Proximity to Water Bodies:** Water bodies in Nepal, such as the Bagmati, Bishnumati, and Koshi rivers, as well as lakes like Phewa and Rara, are essential for maintaining ecological balance and supporting local communities. Constructing EVCSs too close to these areas can lead to several environmental challenges:
- **Pollution from Construction Activities:** The construction of EVCSs involves land clearing, excavation, and the use of heavy machinery, which can result in soil erosion and sedimentation in nearby water bodies. Sediment runoff can degrade water quality, harm aquatic life, and disrupt ecosystems. In urban areas like Kathmandu, where rivers are already heavily polluted, additional construction activities near water bodies could exacerbate the problem.
- **Chemical Contamination:** EVCSs require electrical equipment and, in some cases, battery storage systems that may contain hazardous materials. Leakage or improper disposal of these materials can lead to chemical contamination of nearby water sources, posing risks to both human health and the environment. For example, the Bagmati River, which flows through Kathmandu, is already struggling with pollution from industrial and domestic waste, and further contamination could have severe consequences.
- **Disruption of Green Spaces:** Green spaces, such as parks and wetlands, often surround urban water bodies and play a crucial role in maintaining ecological balance. The construction of EVCSs in these areas can fragment habitats, reduce biodiversity, and diminish the recreational and aesthetic value of these spaces. In a country like Nepal, where green spaces are limited and highly valued, preserving these areas is essential.

**Using Global Landcover Maps for Strategic Planning:** Global landcover maps provide detailed information on the distribution of water bodies, vegetation, and urban areas, making them invaluable tools for planning the location of EVCSs in Nepal. By analyzing these maps, stakeholders can identify water bodies and ensure that EVCSs are erected at a safe distance. Key steps in this process include:

- **Identifying Water Bodies:** Global landcover maps, such as those provided by the European Space Agency (ESA) or the United States Geological Survey (USGS), can be used to pinpoint the location of rivers, lakes, wetlands, and other water sources in Nepal. This data can be overlaid with urban maps to assess the proximity of potential EVCS sites to these sensitive areas.
- **Establishing Buffer Zones:** To mitigate environmental risks, buffer zones should be established around water bodies. These zones act as protective barriers, preventing construction activities from encroaching on sensitive ecosystems. The size of the buffer zone can vary depending on local regulations and the specific characteristics of the water body. For example, a larger buffer zone may be required for a major river like the Koshi compared to a smaller urban stream.
- **Prioritizing Brownfield Sites:** Instead of constructing EVCSs near water bodies or green spaces, stakeholders can prioritize brownfield sites—abandoned or underutilized

industrial areas—for development. These sites are often located in urban areas and have already been disturbed, minimizing the environmental impact of new construction.

**Benefits of Strategic Location Planning:** Erecting EVCSs far from water bodies offers several benefits:

- **Environmental Protection:** By avoiding proximity to water sources, EVCSs can help preserve water quality, protect aquatic ecosystems, and maintain the ecological functions of green spaces. This is particularly important in Nepal, where water bodies are already under pressure from pollution and climate change.
- **Regulatory Compliance:** Many municipalities in Nepal have regulations governing construction near water bodies. Strategic location planning ensures compliance with these regulations, avoiding legal challenges and fines.
- **Enhanced Public Support:** Locating EVCSs in environmentally responsible areas can enhance public support for EV infrastructure projects. Communities are more likely to embrace initiatives that demonstrate a commitment to sustainability and environmental stewardship.

**Integrating Renewable Energy Solutions:** In areas where EVCSs must be located near water bodies due to space constraints, integrating renewable energy solutions, such as solar panels or wind turbines, can reduce the environmental impact. These systems can power EVCSs without relying on grid electricity, minimizing the risk of contamination and reducing the carbon footprint of the charging infrastructure.

The construction of EVCSs in Nepal must be carefully planned to avoid adverse effects on urban water sources and green spaces. By leveraging global land cover maps to identify water bodies and establish buffer zones, stakeholders can ensure that EVCSs are erected at a safe distance, preserving the integrity of these vital ecosystems. Strategic location planning not only protects the environment but also enhances regulatory compliance and public support, paving the way for the sustainable growth of electric vehicle infrastructure in Nepal.

Classification for parameter for Environmental/ Geographical factor Distance to water resources is presented in below Table.

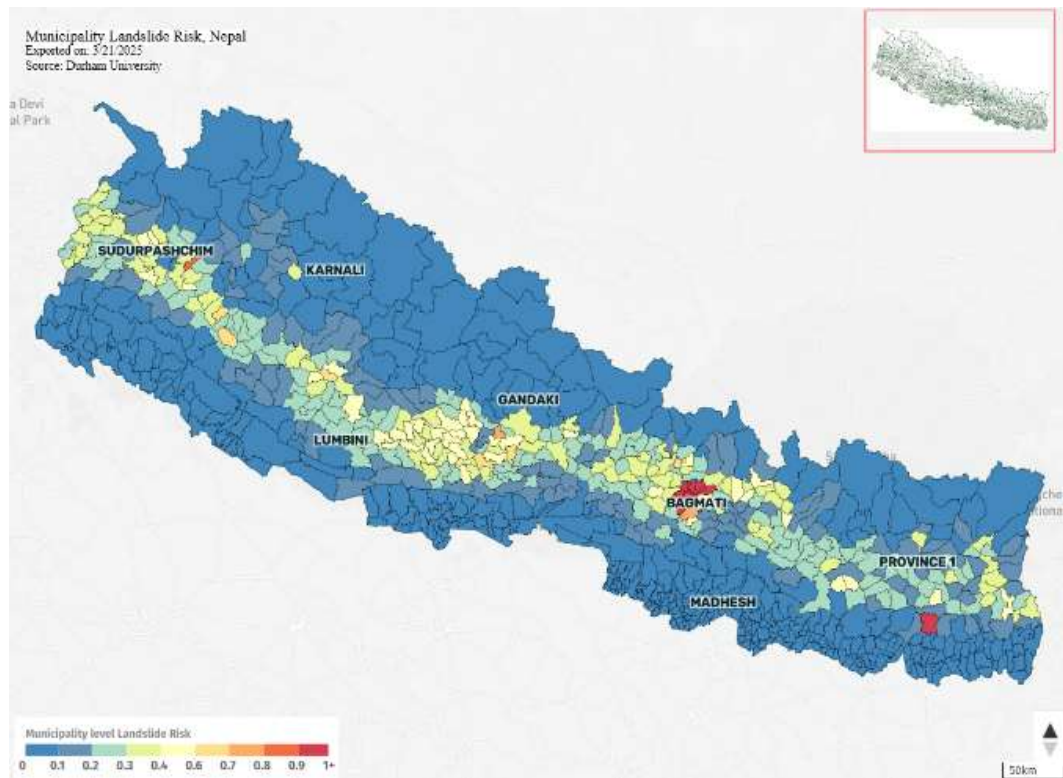
**Table 44: Distance to water resources classification for AHP calculation and mapping**

Distance (m) to water resources WB	Rank	Class	Suitability
500	1	Very Low	Unsuitable
1000	2	Low	Low Suitable
1500	3	Moderate	Moderate Suitable
2000	4	High	Suitable
>2000	5	Very High	High Suitable

### 13. Distance to landslide risk

The EVCSs should not be constructed in landslide hazard areas. In Nepal, a country prone to natural disasters such as landslides, the construction of Electric Vehicle Charging Stations

(EVCSs) must carefully consider geological risks to ensure safety, reliability, and long-term viability. Landslides, triggered by heavy rainfall, earthquakes, and unstable terrain, are a significant hazard in many parts of the country. Constructing EVCSs in landslide-prone areas can lead to infrastructure damage, service disruptions, and safety risks for users. To mitigate these risks, landslide inventory data from sources such as the National Disaster Risk Reduction and Management Authority (NDRRMA), the Bipad Portal, and the Humanitarian Data Exchange can be used to create hazard maps. By applying tools like the Euclidean distance tool, stakeholders can identify safe locations for EVCSs, ensuring they are situated far from landslide-risk zones.



**Figure 27: Municipality level landslide risk map**

(Source: <https://bipadportal.gov.np/risk-info/#/risk>)

**Landslide Risks in Nepal:** Nepal’s rugged topography, combined with monsoonal rains and seismic activity, makes it highly susceptible to landslides. These disasters are particularly prevalent in the hilly and mountainous regions, such as the Mid-Hills and the Himalayan foothills. Landslides can cause significant damage to infrastructure, disrupt transportation networks, and endanger lives. For EVCSs, which require stable ground and reliable access, constructing in landslide-prone areas is not only risky but also economically unviable due to the potential for frequent repairs and service interruptions.

**Landslide Inventory Data and Mapping:** To avoid landslide-prone areas, accurate and up-to-date landslide inventory data is essential. Key sources of this data in Nepal include:

- **National Disaster Risk Reduction and Management Authority (NDRRMA):** The NDRRMA maintains comprehensive records of landslide events, including their

locations, causes, and impacts. This data is critical for understanding historical landslide patterns and identifying high-risk zones.

- **Bipad Portal:** The Bipad Portal is a disaster risk reduction platform that provides geospatial data on landslides and other natural hazards. It offers detailed maps and risk assessments that can be used to inform the placement of EVCSs.
- **Humanitarian Data Exchange:** This platform provides open-access datasets on landslides and other disasters, which can be used to supplement local data and improve the accuracy of hazard maps.

Using this data, a landslide hazard map can be prepared by plotting landslide points and applying spatial analysis tools like the Euclidean distance tool in Geographic Information Systems (GIS) software. The Euclidean distance tool calculates the straight-line distance from each landslide point, creating a buffer zone that indicates areas at risk.

**Applying the Euclidean Distance Tool:** The Euclidean distance tool is a GIS-based method for measuring the distance from a specific point (in this case, landslide locations) to surrounding areas. By applying this tool, stakeholders can:

- **Identify High-Risk Zones:** Areas within a certain distance of landslide points can be classified as high-risk zones. For example, a buffer zone of 500 meters to 1 kilometer around landslide points might be designated as unsuitable for EVCS construction, depending on the severity and frequency of landslides in the region.
- **Create Safe Zones:** Areas outside the buffer zones can be identified as safe for EVCS construction. These zones are less likely to be affected by landslides, ensuring the stability and longevity of the charging infrastructure.
- **Prioritize Low-Risk Areas:** By overlaying the landslide hazard map with other datasets, such as road networks and population density, stakeholders can prioritize low-risk areas that are also accessible and convenient for EV users.

**Benefits of Avoiding Landslide-Prone Areas:** Constructing EVCSs in safe, low-risk areas offer several advantages:

- **Safety and Reliability:** Locating EVCSs far from landslide-prone areas ensures the safety of users and the reliability of the charging infrastructure. This is particularly important in Nepal, where landslides can occur suddenly and with devastating consequences.
- **Cost-Effectiveness:** Avoiding high-risk areas reduces the need for frequent repairs and maintenance, lowering operational costs and improving the financial viability of EVCSs.
- **Public Confidence:** Building EVCSs in safe locations enhances public confidence in the charging network, encouraging greater adoption of electric vehicles.

**Integrating Landslide Risk into Urban Planning:** Landslide risk assessment should be integrated into broader urban and transportation planning efforts. By collaborating with organizations like the NDRRMA and using platforms like the Bipad Portal, stakeholders can ensure that EVCSs are part of a resilient and sustainable infrastructure network. Additionally,

incorporating landslide risk data into zoning regulations can help prevent the construction of critical infrastructure in hazardous areas.

In Nepal, where landslides are a significant natural hazard, the construction of EVCSs must be guided by accurate landslide risk assessments. By leveraging landslide inventory data from sources like the NDRRMA, Bipad Portal, and Humanitarian Data Exchange, and applying tools like the Euclidean distance tool, stakeholders can identify safe locations for EVCSs. This approach not only ensures the safety and reliability of charging infrastructure but also supports the sustainable growth of Nepal's electric vehicle ecosystem. By integrating landslide risk into planning processes, Nepal can build a resilient and future-proof EV charging network that benefits both users and the environment.

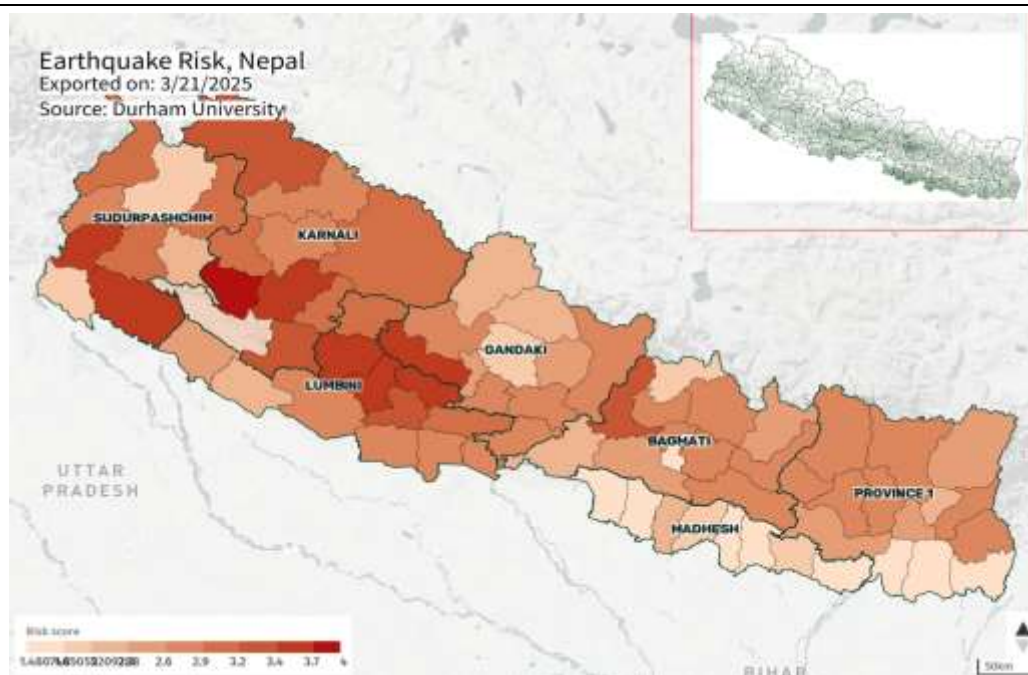
Classification for parameter for Environmental/ Geographical factor landslide risk is presented in below Table.

**Table 45: Landslide risk classification for AHP calculation and mapping**

<b>Distance (m) to Landslide Risk LSR</b>	<b>Rank</b>	<b>Class</b>	<b>Suitability</b>
500	1	Very Low	Unsuitable
1000	2	Low	Low Suitable
1500	3	Moderate	Moderate Suitable
2000	4	High	Suitable
>2000	5	Very High	High Suitable

#### 14. Earthquake Risk Zone

The EVCSs should be constructed away from earthquake areas (fault lines). Nepal, situated in a seismically active region along the boundary of the Indian and Eurasian tectonic plates, faces a high risk of earthquakes. Given this vulnerability, the planning and construction of Electric Vehicle Charging Stations (EVCSs) must incorporate earthquake risk mitigation strategies to ensure safety and resilience. A crucial aspect of this planning involves selecting appropriate locations that minimize exposure to seismic hazards, using available risk data from the Bipad portal and the National Disaster Risk Reduction and Management Authority (NDRRMA).



**Figure 28: Municipality level earthquake risk map**

(Source: <https://bipadportal.gov.np/risk-info/#/risk>)

**Importance of Avoiding Fault Lines:** The placement of EVCSs should prioritize sites away from known fault lines and high-risk seismic zones. Fault lines are areas where tectonic plates meet and generate earthquakes. Building EVCSs in such locations can result in severe structural damage, leading to prolonged service disruptions and potential hazards to users. Identifying these fault lines requires thorough seismic hazard assessments and referencing geological surveys conducted by Nepal’s Department of Mines and Geology. By using the Bipad portal and NDRRMA’s inventory risk score data, authorities can determine regions with the highest earthquake probabilities. These risk scores consider historical earthquake occurrences, ground motion predictions, soil stability, and structural vulnerabilities. Utilizing these datasets enables informed decision-making for site selection and helps minimize potential damages from future earthquakes.

**Data-Driven Site Selection Approach:** The Bipad portal, developed as part of Nepal’s disaster risk management strategy, provides critical real-time data and historical records on disaster events, including earthquakes. This platform, integrated with NDRRMA’s hazard mapping, offers geospatial analysis tools to identify locations with minimal seismic risk. By integrating these datasets, planners can:

- **Assess Seismic Hazard Zones:** Identify areas with frequent seismic activity and avoid placing EVCSs in such locations.
- **Evaluate Ground Stability:** Consider soil liquefaction potential and ground deformation risks, which influence infrastructure stability.
- **Analyze Inventory Risk Scores:** Use NDRRMA’s data to rank potential locations based on seismic vulnerability and select safer alternatives.

- **Incorporate Secondary Hazards:** Evaluate risks of landslides, floods, and other cascading hazards that may arise due to earthquakes.

**Engineering and Structural Resilience:** For locations that may still be at moderate seismic risk, engineering solutions must be implemented to enhance the resilience of EVCS infrastructure. Key measures include:

- **Seismic-Resistant Foundations:** Using flexible foundations that absorb ground motion, reducing structural damage.
- **Shock-Absorbing Materials:** Employing materials with high energy dissipation properties in station design.
- **Backup Power Systems:** Ensuring the availability of alternative energy sources in case of power grid failure during an earthquake.
- **Flexible Grid Connections:** Implementing underground or reinforced transmission lines to withstand seismic forces.

**Policy Recommendations:** To effectively integrate earthquake risk considerations in EVCS deployment, Nepal's government and private stakeholders should:

- **Mandate Seismic Risk Assessments:** Require assessments as part of EVCS site approval processes.
- **Incentivize Safe Construction:** Provide tax benefits for investing in earthquake-resistant technologies.
- **Develop Emergency Response Plans:** Ensure quick recovery and restoration of EVCS functionality after seismic events.

Given Nepal's susceptibility to earthquakes, prioritizing seismic risk mitigation in EVCS planning is essential. By leveraging risk score data from the Bipad portal and NDRRMA, authorities can strategically locate EVCSs in safer zones and implement engineering measures to enhance resilience. Through proactive planning and policy support, Nepal can build a robust and earthquake-resistant EVCS network, ensuring uninterrupted service and long-term sustainability in the country's push toward electric mobility.



**Figure 29: Major Active faults**

Classification for parameter for Environmental/Geographical factor Earthquake risk is presented in below Table.

**Table 46: Earthquake risk classification for AHP calculation and mapping**

Distance from Fault	Rank	Class	Suitability
500	1	Very Low	Unsuitable
1000	2	Low	Low Suitable
1500	3	Moderate	Moderate Suitable
2000	4	High	Suitable
>2000	5	Very High	High Suitable

## 15. Distance to Existing EVCSs

New EVCSs should be built at a distance from other EVCSs that are already in place. The strategic placement of Electric Vehicle Charging Stations (EVCSs) along national highways in Nepal is a critical factor in promoting the adoption of electric vehicles (EVs) and ensuring the convenience of EV users. As Nepal transitions towards sustainable transportation, the distance between new EVCSs and existing ones must be carefully planned to optimize coverage, reduce redundancy, and ensure efficient utilization of resources. The Nepal Electricity Authority (NEA), which oversees the existing EVCS infrastructure, plays a pivotal role in providing data and insights to guide this process.



**Figure 30: Existing charging stations map of Nepal**

(Source: <https://chargingstationsnepal.com/>)

**Importance of Optimal Distance between EVCSs:** The distance between EVCSs is a key consideration for several reasons. First, it ensures that EV users have access to charging facilities at regular intervals, reducing range anxiety—the fear of running out of battery power before reaching the next charging station. Second, it prevents the over-concentration of EVCSs in specific areas, which could lead to underutilization and inefficiencies. Third, a well-

distributed network of EVCSs encourages the use of EVs for long-distance travel, which is essential for national highways connecting major cities and regions.

**Current State of EVCSs in Nepal:** The NEA has already established a number of EVCSs along key national highways, such as the East-West Highway, which spans the length of the country. These stations are strategically located in urban centers, major transit points, and areas with high traffic volume. However, as the number of EVs on the road increases, there is a growing need to expand the network and ensure that charging stations are accessible in more remote and underserved areas.

**Data Collection and Analysis:** To determine the optimal distance for new EVCSs, data from the NEA on the locations of existing stations is essential. This data includes geographic coordinates, capacity, usage rates, and proximity to major highways. By analyzing this information, planners can identify gaps in the current network and prioritize areas where new stations are needed. Geographic Information Systems (GIS) can be used to map existing EVCSs and visualize their distribution, making it easier to identify underserved regions.

**Recommended Distance Between EVCSs:** The ideal distance between EVCSs depends on several factors, including the average range of EVs, traffic patterns, and the topography of the region. In Nepal, where mountainous terrain and varying road conditions are common, the distance between stations may need to be shorter than in flat, urban areas. A general guideline is to place EVCSs every 50-100 kilometers along national highways. This ensures that even EVs with shorter ranges can travel comfortably between stations. Additionally, stations should be located near amenities such as restaurants, rest areas, and hotels to enhance user convenience.

**Challenges and Considerations:** One of the main challenges in determining the distance between EVCSs is the varying demand for charging services. In densely populated areas or regions with high EV adoption rates, more frequent stations may be required. Conversely, in rural or less-traveled areas, fewer stations may suffice. Planners must also consider the availability of electrical infrastructure as remote areas may require significant upgrades to support new EVCSs.

The placement of new EVCSs at an optimal distance from existing ones is crucial for building a robust and user-friendly charging network along Nepal's national highways. By leveraging data from the NEA and employing advanced planning tools, policymakers can ensure that the expansion of EVCS infrastructure meets the needs of EV users while promoting sustainable transportation. A well-distributed network of charging stations will not only reduce range anxiety but also encourage more people to switch to electric vehicles, contributing to Nepal's goals of reducing carbon emissions and dependence on fossil fuels.

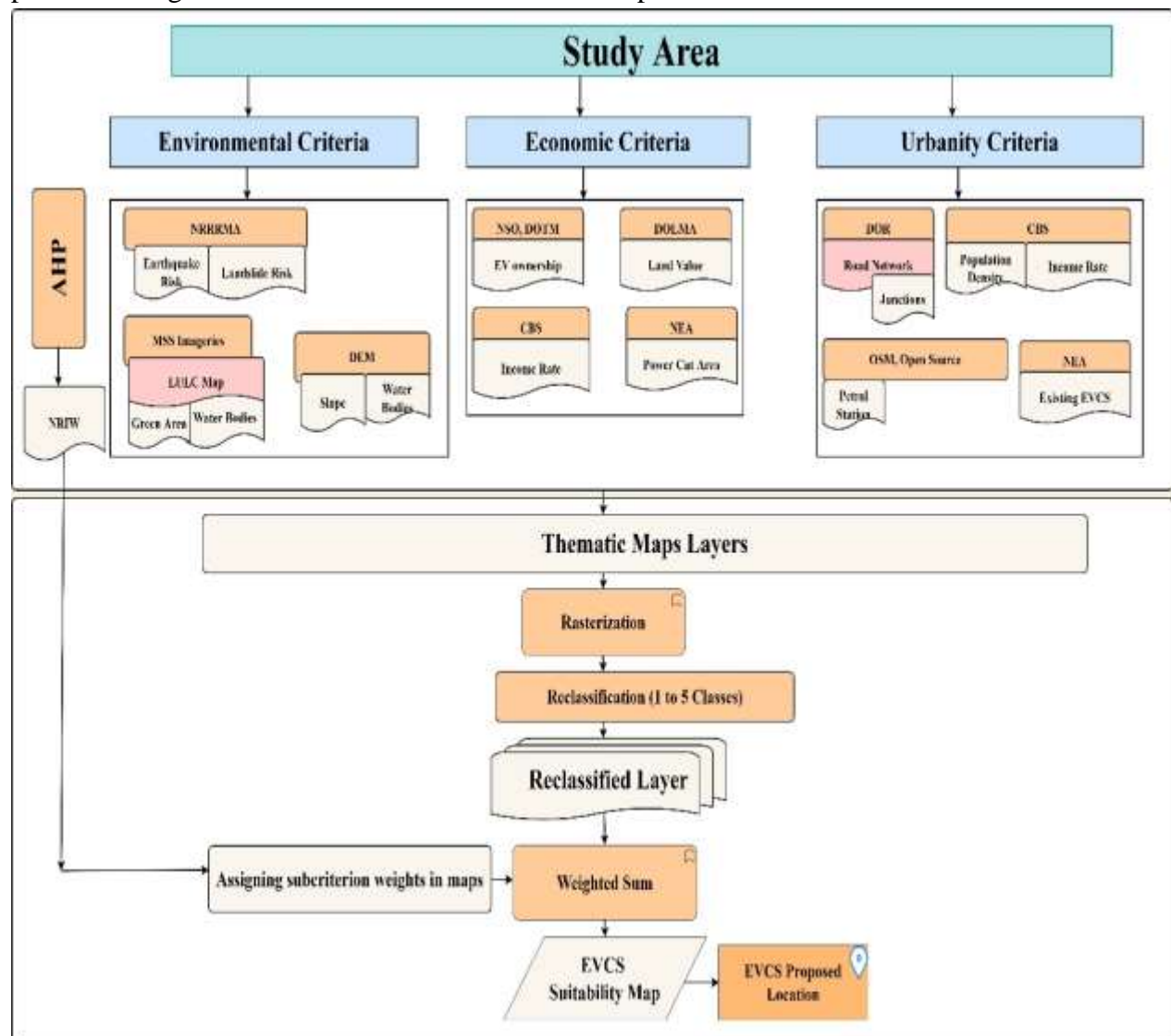
Classification for parameter for Urbanity factor distance from existing EVCS is presented in below Table.

**Table 47: Distance from existing EVCS classification for AHP calculation and mapping**

Distance (m) from Existing CS (EVCS)	Rank	Class	Suitability
500	1	Very Low	Unsuitable
1000	2	Low	Low Suitable
1500	3	Moderate	Moderate Suitable
2000	4	High	Suitable
>2000	5	Very High	High Suitable

**4.5.2.2. Working Methodology for GIS-based EVCSs Analysis Model**

The Working Methodology for GIS-based MCDA AHP EVCSs Analysis Model in the provided image can be broken down into detailed steps as follows:



**Figure 31: Working Methodology for GIS-based MCDA AHP EVCSs Analysis Model**

**Step 1: Define the Study Area (Nepal):** The study focuses on Nepal, covering both urban and rural areas. Given Nepal's diverse topography, it is crucial to identify regions where EVCS can be efficiently placed.

**Step 2: Identifying Criteria for EVCS Site Selection:** The site selection process is based on three main categories:

**Environmental Criteria (Natural & Geophysical Factors)**

- **Earthquake Risk & Landslide Risk (NDRRMA):** Nepal is highly prone to earthquakes and landslides. Charging stations should be placed in stable regions to minimize risk.
- **Land Use Land Cover (LULC) Map (MSS Imageries):** Helps in identifying green areas, water bodies, and urban zones. Charging stations should avoid green areas and water bodies.
- **Digital Elevation Model (DEM):** Used for analyzing slope and water bodies. Flat terrains are preferred for infrastructure stability.

**Economic Criteria (Financial and Market Considerations)**

- **EV Ownership (NSO, DOTM):** Identifies regions with high EV usage, ensuring maximum demand.
- **Land Value (DOLMA):** Helps in selecting cost-effective locations for infrastructure development.
- **Income Rate (CBS):** High-income areas might see a greater demand for EV charging stations.
- **Power Cut Areas (NEA):** Ensures that selected locations have a stable electricity supply.

**Urbanity Criteria (Infrastructure and Population Factors)**

- **Road Network & Junctions (DOR):** Proximity to major highways, roads, and intersections ensures accessibility.
- **Population Density (CBS):** Densely populated areas indicate a higher need for charging stations.
- **Existing Petrol Stations (OSM, Open Source):** Helps in integrating EV infrastructure with traditional refueling stations.
- **Existing EVCS Locations (NEA):** Avoids placing EVCS in redundant areas and helps in network optimization.

**Step 3: Applying AHP for Weight Assignment:** The Analytic Hierarchy Process (AHP) is used to assign weights to each criterion. Normalized Relative Importance Weights (NRIW) are computed. Higher weights are assigned to critical factors like road networks and EV ownership.

**Step 4: Thematic Map Layer Preparation:** The selected criteria are converted into spatial layers in GIS. Each thematic map represents a single decision criterion.

**Step 5: Rasterization of Thematic Layers:** Vector data is converted into raster format to facilitate spatial analysis. Ensures uniformity across multiple criteria.

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**Step 6: Reclassification of Raster Layers:** Raster layers are reclassified into five categories (1 to 5 scale):

1 (Least Suitable) → 5 (Most Suitable). Standardization allows comparison and integration of different factors.

**Step 7: Weighted Sum Analysis:** The Weighted Sum Model (WSM) is applied. Reclassified layers are combined using assigned weights from AHP. This results in the final EVCS suitability score for each location.

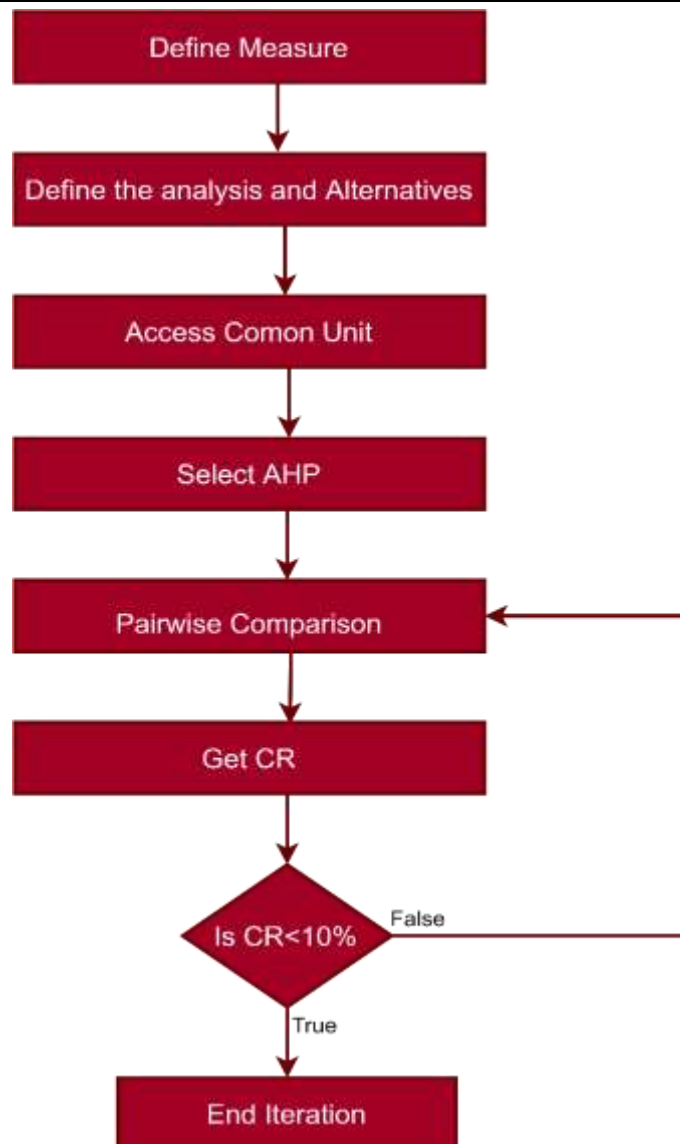
**Step 8: EVCS Suitability Mapping & Proposed Locations:** The final output is an EVCS Suitability Map. The most optimal EVCS locations are identified. The proposed locations are validated with real-world data.

The GIS-based MCDA AHP model provides a systematic and efficient site selection framework for EVCS placement across Nepal. It considers environmental, economic, and urban factors. It optimizes accessibility, demand, and cost-effectiveness. It ensures sustainable and strategic EV infrastructure development. This hybrid GIS-MCDA approach can be applied to other smart city investments in Nepal, such as renewable energy, transportation, and urban planning.

#### **4.5.2.3. AHP Workflow and Computations**

The following steps summarize the process of generating the normalized relative importance weights for the parameters at level 2, level 3 and creating the model.

- a) **Modelling the problem:** In order to achieve the project's goal, the first step is to set the parameters, which takes into account all stakeholders, goals, and the resulting outcomes. The decision elements are arranged in a hierarchical structure that includes the goal, criteria, and sub-criteria. The different types of criteria are grouped together as sub-criterion. As far as AHP goes, this is the most critical step.
  
- b) **Deriving the overall weight of the criteria and sub-criteria using Logical Decisions Software Version 7.2:** Here, ratings are gathered for all criteria and sub-criteria using a pairwise comparison technique and a scale of relative importance (see Table), as shown in Table. Following the pairwise comparison, the relative importance weights of the criteria are normalized in terms of the goal's attainment and the relative importance weights of the sub-criteria are determined with respect to the criteria. This method was primarily used to calculate the weight, which ensures that all of the other variables are also unbiased. We used logical decision software to calculate NRIW. The process generally includes a visit to the field and a questionnaire for comparing all the elements to reach a group consensus. The importance of each parameter was determined by ranking each one. There are three ways to calculate NRIW in this program: by using NRIW as a vector and by using the Eigen value consistency index and Eigen value consistency ratio as inputs. The CR must be less than 10% for the computed NRIW to be valid. It is an iterative process if the process is repeated until it meets the requirements. To compute AHP, follow this workflow.



**Figure 32 : Workflow for Computation using AHP**

In the table below, the diagonal elements show the Normalized Relative Importance Weight, and the largest Eigen value, consistency index, and consistency ratio are all found in the top left corner. In the beginning, the software needs to define the measurement, and then the analysis and alternatives must be specified. The access Common Unit menu consists of different analysis access such as AHP, adjusted AHP, ideal AHP, and Balance Beam Method. We were able to gain access to AHP as one of these. Then we created a pairwise comparison matrix for all of the major parameters and sub-classes. The process came to an end when the iteration process reached an acceptable CR value.

#### **4.5.2.4. Normalized Relative Importance Weight for different parameter and expert questions**

The Normalized Relative Importance Weight (NRIW) is computed for main criteria (Level 2) is given below. Which shows comparison matrix for selected parameters: Environmental/ Geographical factor (Distance to Vegetation/ Green Areas, Distance to water resources,

Distance to landslide risk, Slope of Land, Earthquake risk), Economic Factor (Land Value, Income Rates, Electric Vehicle ownership in the service area, Distance to power cut area), Social factor (population density), Economic factor (distance from economic centers, land value), Urbanity Factor (Service area population, Proximity to Junction, Transportation Station, Proximity to Road, Proximity to petrol station, Distance to other EVCSs). In this study each parameter from five major criteria were taken for suitability analysis (Suleyman Sisman, Irem Ergul, 2021).

AHP table and Normalized Relative Importance Weight (NRIW) of different questions and answers from the expert are presented in ANNEX IX. The average weight of all parameters from experts answer questions which are presented below.

**Table 48: Average Weight From AHP**

<b>Factors</b>	<b>Symbol</b>	<b>Average Weight From AHP</b>
Green Areas/Vegetation	GV	0.0479
Land slope	LS	0.0445
Land Values	LV	0.0458
Petrol Stations	PS	0.0850
Transportation Stations	TS	0.0775
Income Rate	IR	0.0719
Road Network	RN	0.0996
Population Density	PD	0.0858
Junctions (Nodes)	JN	0.0770
Distance to Power Cut Area	DPA	0.0464
Electric Vehicle Ownership	EVO	0.0832
Water Bodies	WB	0.0413
Landslide Risk Zone	LRZ	0.0364
Earthquake Risk Zone	EQZ	0.0381
Existing Electric Vehicle Charging Station	EEVCS	0.1196

The literature examined the effects of EVCS site selection on criterion and criteria weights. The three primary criteria groups the Economic Criteria, the Urbanity Criteria, and the Environmental/Geographical Criteria defined 15 criteria for this purpose. The criteria weights coefficients, which define the relative relevance of the criteria, were established in accordance with (Erbaş, Kabak, Özceylan, & Çetinkaya, 2018). Table below provided an explanation of the main criterion, sub-criteria, and definition along with the criteria weights.

Examining below Table, it was found that the urbanity criteria had the greatest major criteria group weight. However, distance to other EVCSs received the largest weight in the Urbanity criterion group, EV ownership in the service area in the Economic Criteria group, and distance to vegetation in the Environmental/Geographical criterion group.

**Table 49: Weights of criteria computed AHP method**

<b>Main criteria</b>	<b>Sub-criteria</b>	<b>Weights</b>
Environmental/ Geographical Criteria <b>(0.2082)</b>	Distance to Vegetation/ Green Areas	0.0479
	Distance to water resources	0.0413
	Distance to landslide risk	0.0364
	Slope of Land	0.0445
	Earthquake risk	0.0381
Economic Criteria <b>(0.2473)</b>	Land Value	0.0458
	Income Rates	0.0719
	Electric Vehicle ownership in the service area	0.0832
	Distance to Power cut area	0.0464
Urbanity Criteria <b>(0.5445)</b>	Service area Population	0.0858
	Proximity to Junctions	0.077
	Transportation Station	0.0775
	Proximity to Road	0.0996
	Proximity to petrol station	0.085
	Distance to other EVCSs	0.1196

4.5.2.5. GIS-based model design

The model builder tool in ArcGIS 10.5 and ArcGIS Pro software was used to create two models for the GIS-based evaluation of possible locations for EVCS construction.

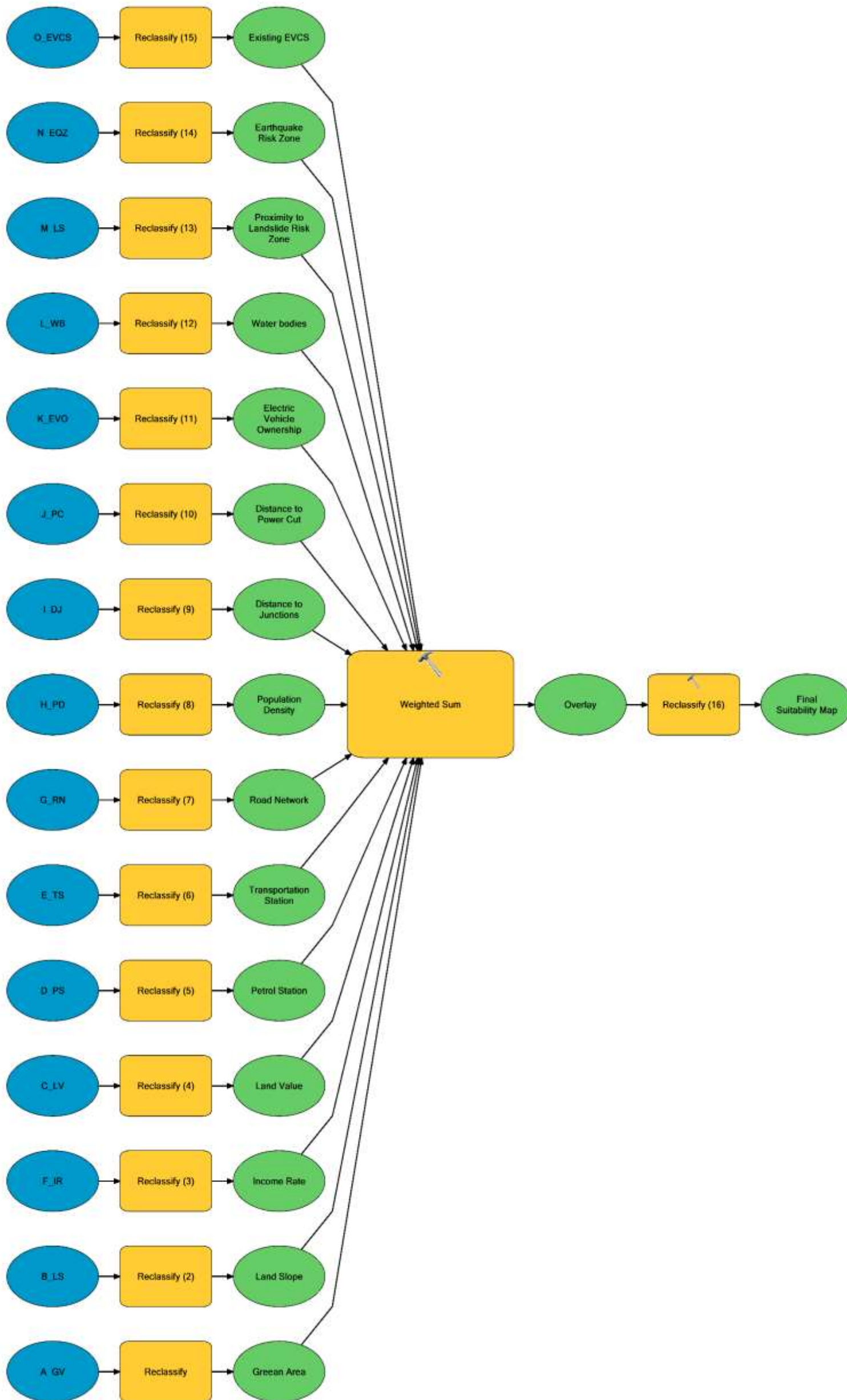


Figure 33: GIS-based model design

#### **4.5.2.6 Data Preparation and Site Selection Modeling Using GIS Techniques**

Data preparation was the initial model, and it applies to all site selection models. Euclidean distance, slope, inverse distance weighted, and kernel density geographical analysis techniques were used to create the raster layers in this model. The analytic methods for the 15 criteria influencing the choice of EVCS location were applied in the second model. The procedure was carried out in two stages. Using the raster calculator tool, all criteria were normalized in the 1 to 5 range in the first stage.

Maps that were created were then classed. The relevance levels of the EVCS criteria in the combining process (by weighted sum analysis) of the layers generated by the data preparation model were taken into account in the second stage using the criteria weights specified in Table 49. However, raster maps with a full value of 5 were created since there was insufficient data for the two criterion (1 - EV ownership in the service region, and 2 - Risk Data). The functioning of the intended model is unaffected by this circumstance.

The selection of suitable locations for Electric Vehicle Charging Stations (EVCS) is a complex process that requires a Geographic Information System (GIS)-based approach to analyze spatial and non-spatial data effectively. The use of GIS tools, such as the Model Builder in ArcGIS 10.5 and ArcGIS Pro, facilitates an objective evaluation of potential sites. This study presents a GIS-based model designed to assess optimal locations for EVCS by integrating multiple geographical and socio-economic criteria.

The model design consists of two primary stages:

- a. Data Preparation Model
- b. Site Selection Model

**a. Data Preparation Model:** This initial phase involves gathering and processing various spatial data layers that are essential for site selection analysis. The following geographical analysis techniques were employed:

- **Euclidean Distance Analysis:** Determines the straight-line distance from specific features such as roads, urban centers, and existing charging stations.
- **Slope Analysis:** Identifies terrain inclination to ensure accessibility and feasibility of construction.
- **Inverse Distance Weighted (IDW) Interpolation:** Generates spatially distributed data from known points, useful for estimating attributes like population density.
- **Kernel Density Analysis:** Helps in identifying areas with high demand based on parameters like traffic flow and urban activity.

These techniques result in multiple raster layers representing spatial influences on the selection process.

**Step 1: Criteria Normalization:** All selected criteria were normalized within a 1 to 5 scale using the Raster Calculator tool in ArcGIS. The normalization ensures that different criteria are comparable and can be effectively combined.

**Step 2: Weighted Sum Analysis:** Once normalized, the raster layers were combined using a weighted sum approach. The weightings for each criterion were assigned based on Table 48, which ranks the relative importance of different factors such as proximity to major roads, population density, and availability of power supply.

**Handling of Data Deficiencies:** In cases where data was insufficient, such as for EV ownership in the service region and Risk Data, raster maps were created with a full value of 5. This assumption does not negatively impact the model's functionality, as the weight-based combination accounts for such uncertainties.

**Output and Interpretation:** The final output consists of classified maps displaying suitable and unsuitable locations for EVCS. The classification enables decision-makers to prioritize high-potential sites based on spatial analysis results. This GIS-based model provides a systematic and data-driven approach to evaluating potential EVCS locations. By integrating advanced spatial analysis techniques, it ensures an optimal and efficient distribution of charging stations, supporting the growth of electric mobility infrastructure.

- b. Site Selection Model:** The second stage integrates and evaluates various criteria influencing the location of EVCS. A total of 15 criteria were considered in the analysis. This phase was carried out in two major steps:

**Step 1: Criteria Normalization:** All selected criteria were normalized within a 1 to 5 scale using the Raster Calculator tool in ArcGIS. The normalization ensures that different criteria are comparable and can be effectively combined.

**Step 2: Weighted Sum Analysis:** Once normalized, the raster layers were combined using a weighted sum approach. The weightings for each criterion were assigned based on Table 18, which ranks the relative importance of different factors such as proximity to major roads, population density, and availability of power supply.

**Handling of Data Deficiencies:** In cases where data was insufficient, such as for EV ownership in the service region and Risk Data, raster maps were created with a full value of 5. This assumption does not negatively impact the model's functionality, as the weight-based combination accounts for such uncertainties.

**Output and Interpretation:** The final output consists of classified maps displaying suitable and unsuitable locations for EVCS. The classification enables decision-makers to prioritize high-potential sites based on spatial analysis results. This GIS-based model provides a systematic and data-driven approach to evaluating potential EVCS locations. By integrating advanced spatial analysis techniques, it ensures an optimal and efficient distribution of charging stations, supporting the growth of electric mobility infrastructure.

#### **4.5.2.7. Need for GIS-Based Investment Planning in Smart Cities**

Investment planning in various sectors, including energy, technology, education, health, transportation, industry, logistics, and construction, is integral to the sustainable development of smart cities. As urbanization continues, cities such as those in Nepal must ensure that investments are placed in the most suitable locations to enhance accessibility, functionality,

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and efficiency. GIS-based methodologies play a pivotal role in identifying optimal investment locations by integrating various geographical, environmental, and socio-economic factors.

Traditional investment planning methods often require extensive data analysis and manual processing, which can be time-consuming and less effective. However, GIS-based models allow for automated, data-driven decision-making, making the investment process more streamlined and effective. The integration of GIS and MCDA approaches provides a systematic way to evaluate multiple criteria simultaneously, thereby enabling objective decision-making that supports long-term urban development.

#### **4.5.2.8. Role of GIS and MCDA in Site Selection for EVCS**

One of the significant applications of GIS-based investment planning is the site selection of EVCS. With the rise in the adoption of electric vehicles, the availability of well-located charging stations is crucial for the convenience of users and the success of EV infrastructure. The placement of charging stations must consider various geographical, environmental, economic, and social factors to maximize accessibility and minimize operational challenges.

The GIS-based model developed for EVCS site selection in Nepal follows a structured approach, utilizing two primary models: data preparation and site selection analysis. The data preparation model ensures that all relevant geographic data layers, such as land use, transportation networks, and population density, are processed using spatial analysis techniques like Euclidean distance, slope analysis, inverse distance weighting, and kernel density estimation. These techniques help in generating meaningful raster layers that can be further analyzed in the site selection model.

The site selection model integrates multiple criteria affecting EVCS location choices. This model applies normalization techniques using the raster calculator tool, where all relevant criteria are standardized on a scale of 1 to 5. The criteria are then weighted based on their importance in the decision-making process, as specified in a pre-defined weighting system (e.g., AHP, FAHP, or BWM). This ensures that the most critical factors have a greater influence on the final site selection outcome.

#### **4.5.2.9. Key Factors Considered in GIS-Based EVCS site Selection**

The process of selecting the best EVCS locations involves evaluating multiple factors, which can be classified into four broad categories:

##### **Environmental Factors**

- Land Use and Land Cover (LULC): Identifying suitable land types (e.g., commercial, residential, industrial) for EVCS installation.
- Topography and Slope: Ensuring the location is accessible and feasible for construction, avoiding steep terrain.
- Risk factor: Considering factors such as landslide and earthquake risk that may affect station infrastructure.

##### **Economic Factors**

- **Cost of Land and Infrastructure:** Evaluating the economic feasibility of installing charging stations in specific areas.
- **Electricity Supply and Grid Proximity:** Ensuring that charging stations have access to stable and cost-effective electricity sources.
- **Market Demand for EV Charging:** Identifying regions with high EV ownership and usage rates to maximize station utilization.

### Social and Urbanity Factors

- **Population Density:** Prioritizing areas with higher populations to increase accessibility.
- **Traffic and Commuter Behavior:** Placing stations near highways, public transport hubs, and major roads to optimize convenience.
- **Public Interest and Acceptance:** Considering public opinion and awareness regarding EV adoption in different regions.

### Technological Factors

- **Accessibility to Existing Charging Infrastructure:** Avoiding unnecessary redundancy while ensuring an even distribution of stations.
- **Integration with Smart City Technologies:** Implementing IoT-based monitoring systems for real-time usage analysis and maintenance.
- **Vehicle-to-Grid (V2G) Technology Readiness:** Preparing for future integration with smart grids and renewable energy sources.

### Advantages of GIS-Based Site Selection Models

The implementation of GIS-based models in EVCS site selection offers several advantages:

- **Automation and Efficiency:** The ability to process large datasets rapidly and efficiently to identify optimal locations.
- **Objective Decision-Making:** GIS models integrate MCDA approaches to eliminate bias in site selection.
- **Flexibility and Scalability:** The models can be adapted for different geographical regions and investment types.
- **Cost and Resource Optimization:** Ensures investment is directed towards areas with the highest potential for success.
- **Data-Driven Insights:** Allows urban planners and policymakers to make informed decisions based on spatial analysis.

### Challenges and Limitations

Despite its advantages, GIS-based EVCS site selection faces some challenges:

- **Data Availability and Accuracy:** The accuracy of the model depends on the quality and availability of relevant data, such as EV ownership statistics and risk assessments.

- **Complexity of Multi-Criteria Analysis:** Weighting multiple factors accurately requires expert knowledge and may vary based on location-specific requirements.
- **Dynamic Nature of Urban Development:** Rapid urbanization and changes in land use can affect the long-term validity of selected sites.
- **Technological Constraints:** Some regions may lack the necessary infrastructure to support GIS-based decision-making tools effectively.

**Future Prospects and Research Directions:** The integration of GIS and MCDA for EVCS site selection is a rapidly evolving field. Future research can focus on:

- **Artificial Intelligence (AI) and Machine Learning Integration:** Utilizing AI-driven predictive models to improve the accuracy of site selection.
- **Real-Time Data Analysis:** Incorporating IoT sensors and big data analytics to optimize charging station operations dynamically.
- **Renewable Energy Integration:** Enhancing sustainability by incorporating solar and wind energy sources in EVCS design.
- **Advanced Decision-Making Models:** Exploring hybrid approaches that combine GIS, AI, and decision-making frameworks like fuzzy logic for enhanced accuracy.

GIS-based models provide an effective and systematic approach for selecting optimal locations for electric vehicle charging stations. By integrating multi-criteria decision analysis with GIS technology, urban planners and policymakers can make well-informed decisions that enhance urban mobility and support sustainable development. As the world transitions towards electric mobility, the importance of data-driven site selection methodologies will continue to grow. The GIS-based approach, combined with evolving technologies such as AI, IoT, and smart grid integration, will play a critical role in shaping the future of EV infrastructure planning. By refining and expanding these models, cities can ensure the successful deployment of EVCS networks that support widespread EV adoption and contribute to a cleaner, more efficient transportation system. Ultimately, the development of GIS-based investment models not only improves EVCS site selection but also provides a versatile framework that can be applied to various urban planning initiatives, including smart city development, transportation infrastructure, and renewable energy projects. With continuous advancements in GIS and decision-support systems, cities can move towards a more strategic, data-driven approach to urban development, ensuring efficient resource allocation and sustainable growth.

#### **4.5.2.10. Discussion and Conclusion**

It is essential that various sectoral investments such as those in energy, technology, education, logistics, health, industry, transportation, construction, and tourism that will be undertaken in densely populated, globalizing cities are made in the best possible city locations all over the Nepal. Many investment management choice characteristics should be logically evaluated from an integrated geographical viewpoint in order to maximize the efficiency of the city area for any sectoral investment activity and to create more planned and livable cities. Today, with the development of GIS-based technology and other MCDA approaches, this evaluation may be completed rapidly. In smart cities, a lot of data is utilized to identify and address geographic issues like resource allocation for investment planning and site selection. These data are included in the process based on a variety of criteria. The decision-making process for choosing

appropriate places for any investment activity takes a lengthy time when facts pertaining to several factors are evaluated. MCDA approaches, in which several factors are simultaneously examined from environmental, economic, social, and technological aspects, can be utilized efficiently to expedite the decision-making process and make it more objective. These methods (such as AHP, FAHP, and BWM) can be used to assess the relative relevance of the choice criteria. However, for any type of investment planning, GIS-based models may be created to automate the site selection process. Different geographical analyses on diverse data sets can be carried out automatically by the models that have been created. This allows for the quick completion of detailed geographical activities, which should always be performed using the predefined models. In conclusion, GIS-based site selection models, which combine MCDA and GIS methodologies in a hybrid framework, may be used to create efficient and fast decision-support strategies. An integrated and planned investment system for the remarkable and effective use of urban resources in smart city investments may be created using the models that have been built. To give investors other spatial decision assistance options, the developed models may also be modified for various industry investment applications, such as the notion of smart cities, which involves rather distinct choice situations. These days, the automobile industry is researching technology related to electrical vehicles and vehicle-to-vehicle networks. For these newer cars, site selection and optimization issues have been a significant study topic.

With the rapid expansion of urban centers and the increasing global emphasis on sustainability, the integration of Geographic Information Systems (GIS) and Multi-Criteria Decision Analysis (MCDA) has become a crucial approach for effective urban planning. In particular, GIS-based decision-support models have gained prominence in selecting optimal locations for Electric Vehicle Charging Stations (EVCS). Given the rise of electric vehicles (EVs), it is imperative to ensure that the placement of EVCS infrastructure is conducted in a strategic and data-driven manner to meet the growing demand efficiently.

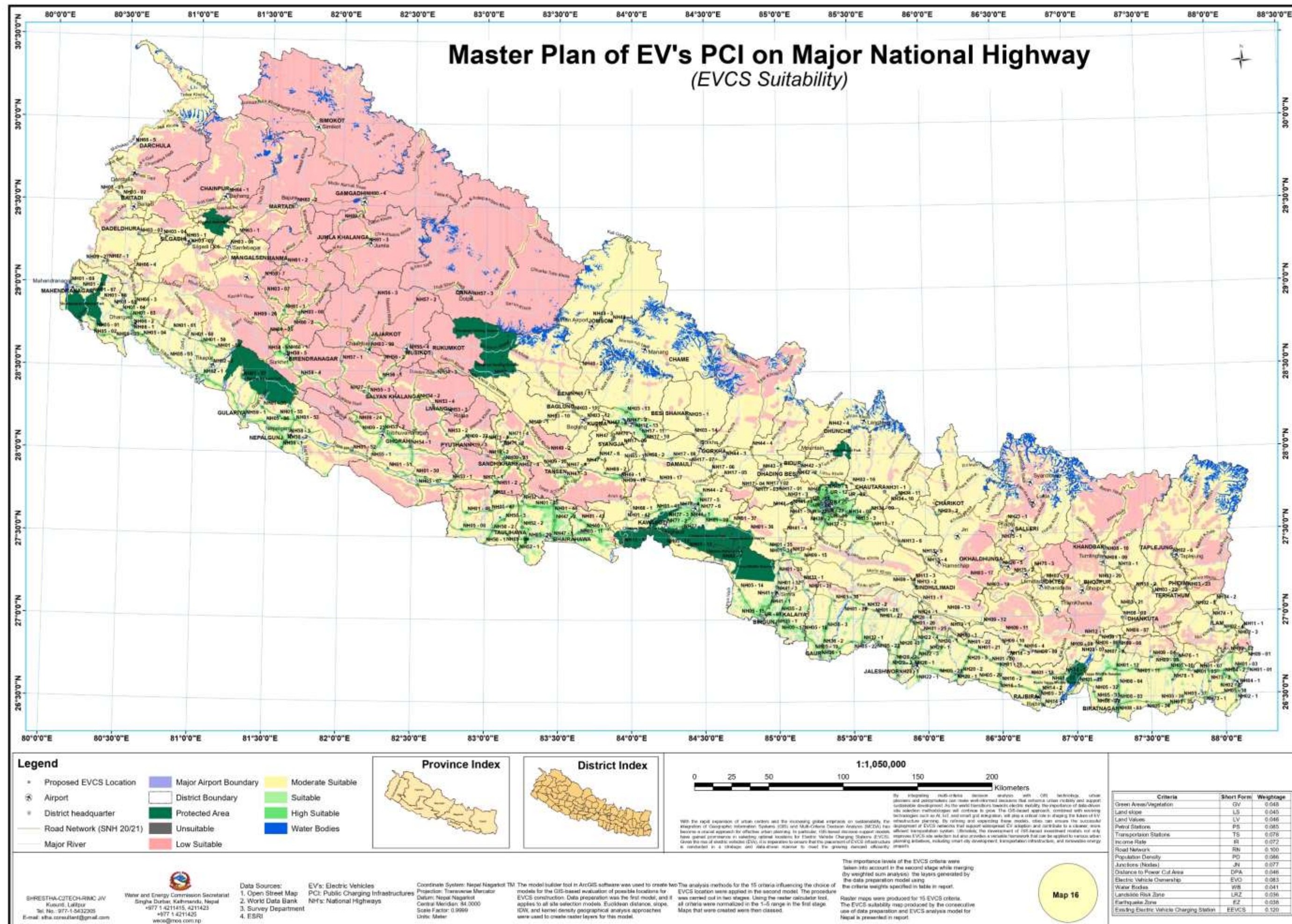


Figure 34 : Suitability map obtained from GIS

After obtaining the suitability map of the charging station using ArcGIS analysis of above-mentioned criteria, the location of the charging station (latitude, longitude) was found out using the following specifications as per the TOR:

In case of Public Charging Stations, the following requirements are laid down with regard to density/distance between two charging points:

- One charging station shall be set up at every 25 km on either sides of highways/ roads, in case of Major City area 3-5 km shall be consider while constructing a charging station along the highway to meet the demands.
- 500m buffer zone has been selected for the studied highway with three suitability classes: Suitable, Moderately Suitable and Marginally Suitable; thus, a charging station is suggested within 200m including ROW and setback.

424 Electric Vehicle Charging Stations has been the output considering above conditions.

Note: The Out put of 424 EVCS Proposed Locations for charging stations along National highway is present in Annex-VII

**4.5.2.11. Inundation Risk Analysis**

Overlaid GIS data (Proposed EVCS location) with flood hazard of ICIMOD, DHM and Flood inundation mapping from HKH region. Which are historical flood events of 2017 and 2022, inundation depths, and Flood return periods to exclude high-risk zones. Only four stations were found inundated. These four stations need to be constructed by filing construction materials and taking some heights (2 – 4m) from the ground surface which will protect the charging station from massive floods. There is a lack of open space and government land in those areas. Maps and data overlaid with the inundation map are presented below.

**Table 50: Inundated proposed EVCS**

St_Code	Name	DISTRICT	MP/RMP	New Ward	ZONE	ILAK A	Old Ward	Lat	Long
EVCS/2151701/NH14 - 1	Tilathi	SAPTARI	Tilathi Koiladi Rural Municipality	1	SAGARMATHA	7	8	26.46	86.77
EVCS/151304/NH05 - 34	Bhawane - Rangeli Rd	MORANG	Rangeli Municipality	4	KOSHI	2	8	26.46	87.47
EVCS/2160402/NH16 - 2	Bhagwanpur	SIRAHA	Bhagawanpur Rural Municipality	2	SAGARMATHA	3	9	26.60	86.49
EVCS/2191804/NH32 - 1	Malangwa	SARLAHI	Municipality	4	JANAKPUR	8	4	26.86	85.56

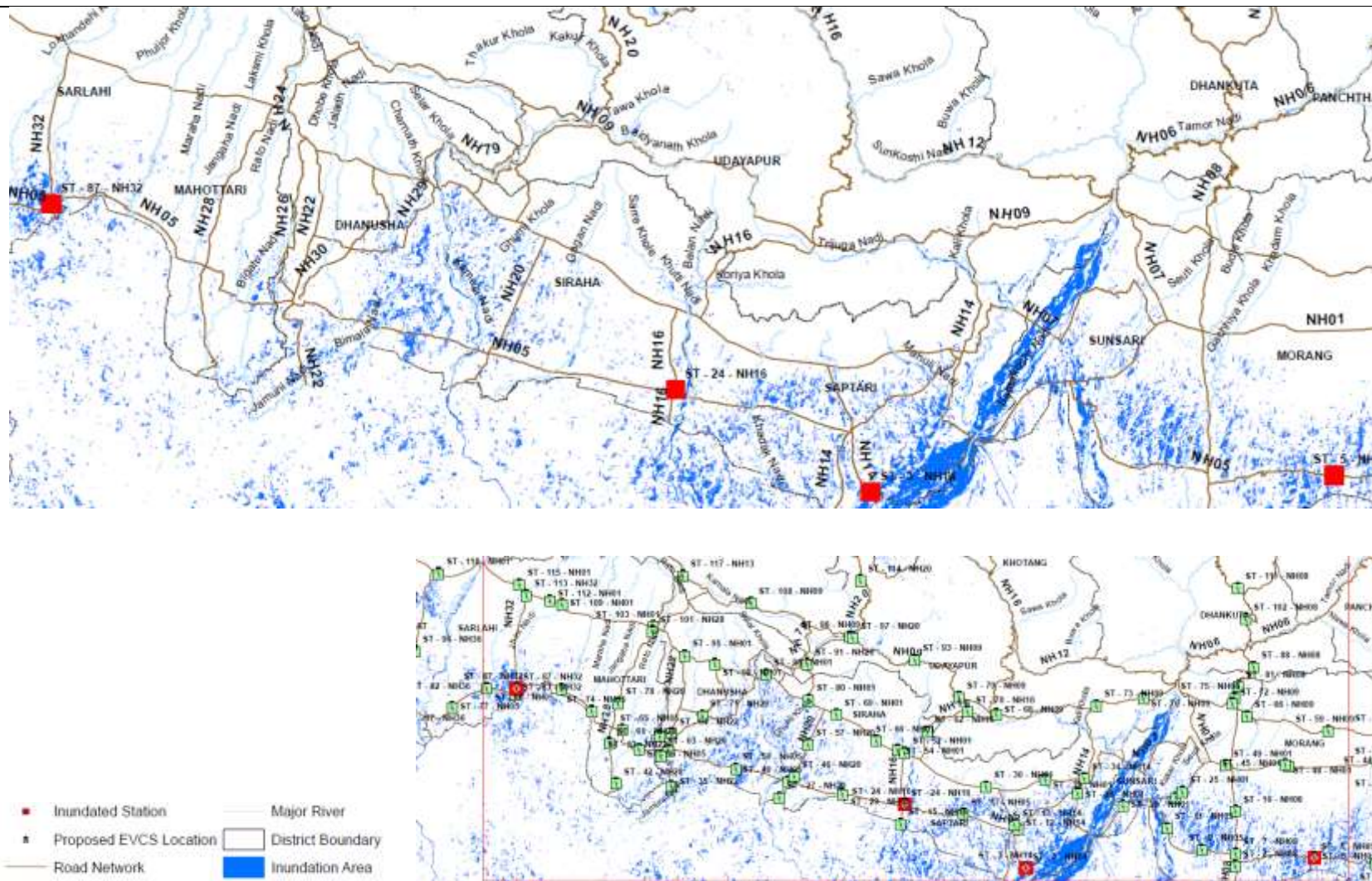


Figure 35: Inundated station and proposed EV charging stations

### 4.5.3. EV chargers and their Layout plan & Electrical Drawing for EVPCI/ Station Layout Plan and Electrical Single Line Diagram of EVPCI/S

It is crucial to keep the amount of space needed for charging stations as low as possible. Therefore, site planning is crucial for integrating EV charging infrastructure. Planning the site will be done so that the least amount of area possible is used while still providing all facilities. Additionally, it depends on the location of the charger and how many and what kind of EV charge stations must be provided there.

There are three primary installation choices for EV charging equipment: pedestal-mounted, pole-mounted and wall-mounted solutions. Equipment for wall-mounted charging is mounted to a wall or other vertical surface. The pole-mounted and wall-mounted solutions is less expensive and takes up less space when compared with pedestal mounted solution.

#### 4.5.3A. EV Chargers, Layout plan and electrical single line diagram (Category I)

Different type of EV charger to be installed for EVPCI/ Station on the NH, Petrol pump and Bus-park (Category I)

SN	EV Segment	Type of EV Charger	Connector and their guns	Number of EV Charger per Charging Station
1	e-2Ws	3.3 kW, 16A, 230V	Type 1,2 AC (1/3 CG)	4
2	e-3Ws	7.4 kW, 32A, 230V	Type 1, 2 AC (1/2 CG)	4
3	e-4Ws	22 kW, 380-480V	Type 2 AC (1/2 CG)	1
4	e-4Ws	60 kW, 200-750V, DCFC	GB/T (1/2 CG)	2
5	e-4Ws	60 kW, 200-750V, DCFC	CHAdEMO (1/2 CG)	1
6	e-4Ws	60 kW, 200-750V, DCFC	CCS-2 (1/2 CG)	1
7	e-4Ws (Car/Bus/Truck)	120 kW, 200-1000V, DCFC	GB/T (1/2 CG)	1

Layout Plan for EVCS Category-I

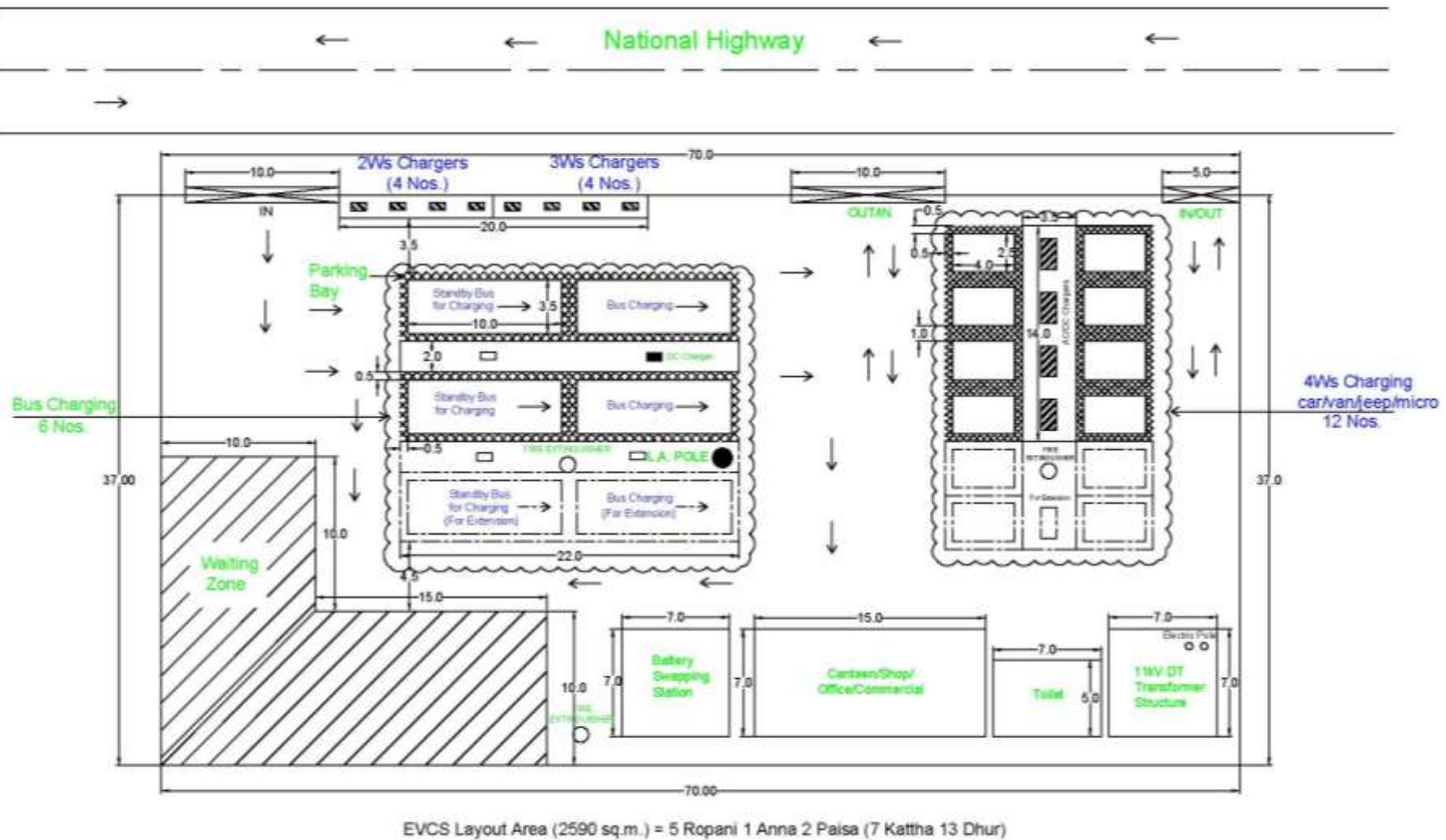


Figure 36 : Layout for EVPCI/ Station for NH, Petrol pump and Buspark. (Category –I)

**Table 51: Coverage Area Calculation for EV PCI/ Station for NH,Petrol pump and Buspark (Category –I)**

SN	Type of EV	No of EV	Size(m)	Area (Sq.m.)
1	Bus/Truck	4 + 2 (2 spares)	11x4.5	297
2	Car/Jeep/Micro/Other 4W	8 + 4 (4 spares)	5x3.5	210
3	Tempo	8	2.5X2.5 (each)	50
4	Motorcycle and Scooter	12	2X2 (each)	32
5	Charging stand Area	2 + 1 + 1	22X2 + 21X3.5 + 10.5X3	149
<b>TOTAL (1+2+3+4+5) =</b>				<b>738</b>
6	Waiting space for EV at same time	16	10X20+10X15	350
7	Toilet	5+5 users	3.5	35
8	Canteen and Others	1	15X7	105
9	Battery Swapping Station	1	7X7	49
10	11kV Distribution Transformer Structure	1	7X7	49
11	Vehicle Movement Area + Greenery + Future Extension	1		1264
<b>TOTAL (1+2+3+4+5+6+7+8+9+10+11) =</b>				<b>2590</b>

Other structures: Lightening Arrester Pole – 1 Nos.; Fire Extinguisher – 3 Nos.

Ropani-Anna-Paisa-Dam= **5 Ropani 1 Anna 2 Paisa**

Bigha-Katha-Dam= **7 Kattha 13 Dhur**

The basic components of an electric vehicle charging station include inlet/outlet, electric vehicle chargers, charging space with bays, charging stand area, battery swapping station, 33/0.4 kV, 11/0.4kV distribution transformer structure, vehicle movement area, greenery, future expansion area, safety facilities, other civil and electrical infrastructures. These components together form a complete electric vehicle charging station, providing convenient and safe charging services for electric vehicles.

Electrical Single line diagram and Load calculation (Category –I)

**Load Calculation:**

SN	Type of Charger	EV Segments	Number of Chargers	Load (kW)	
				Calculation (kW)	Total (kW)
1	3.1 kW	e-2Ws	4	=4*3.1/3	4.13
2	7.4 kW	e-3Ws	4	=4*7.4/3	9.86
3	22 kW	e-4Ws	1	=1*22/1	22
4	60 kW	e-4Ws	4	=4*60/1	240
5	120 kW	e-4Ws (Bus/Truck)	1	=1*120/1	120
6	Lighting				5
<b>Total</b>					<b>400.99 kW</b>

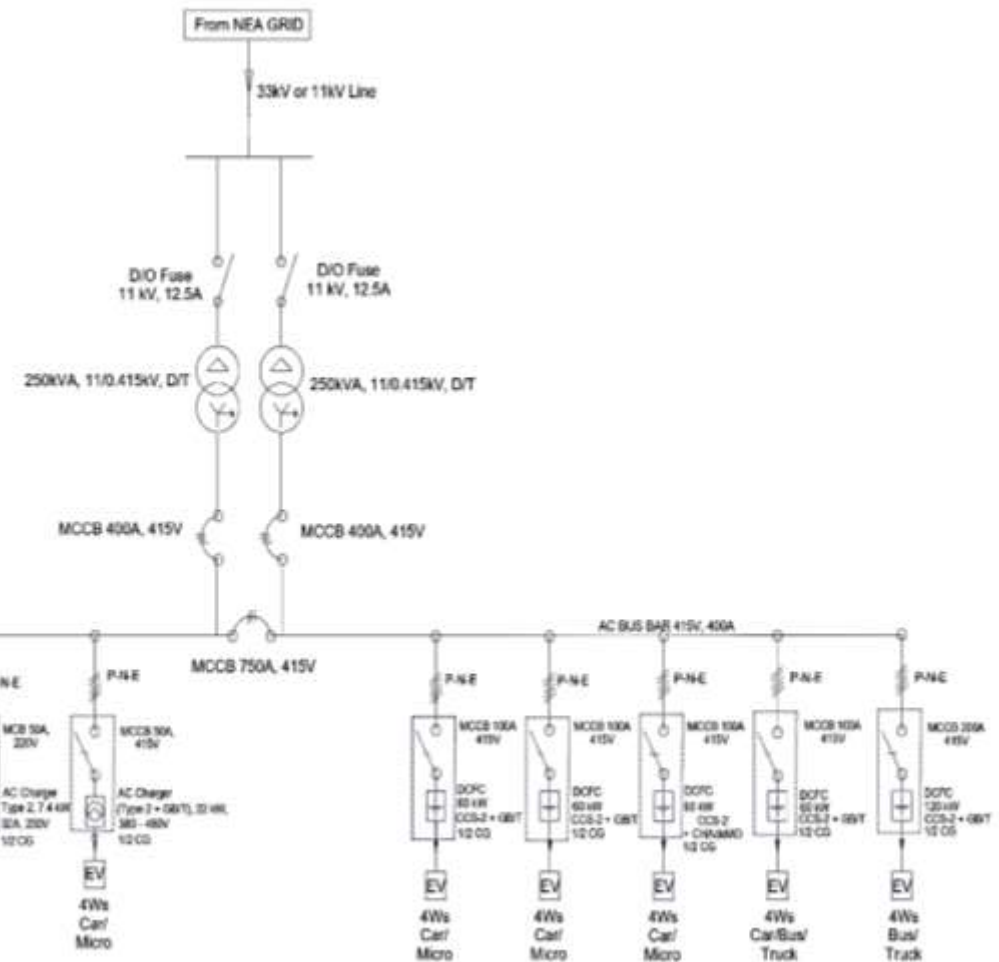


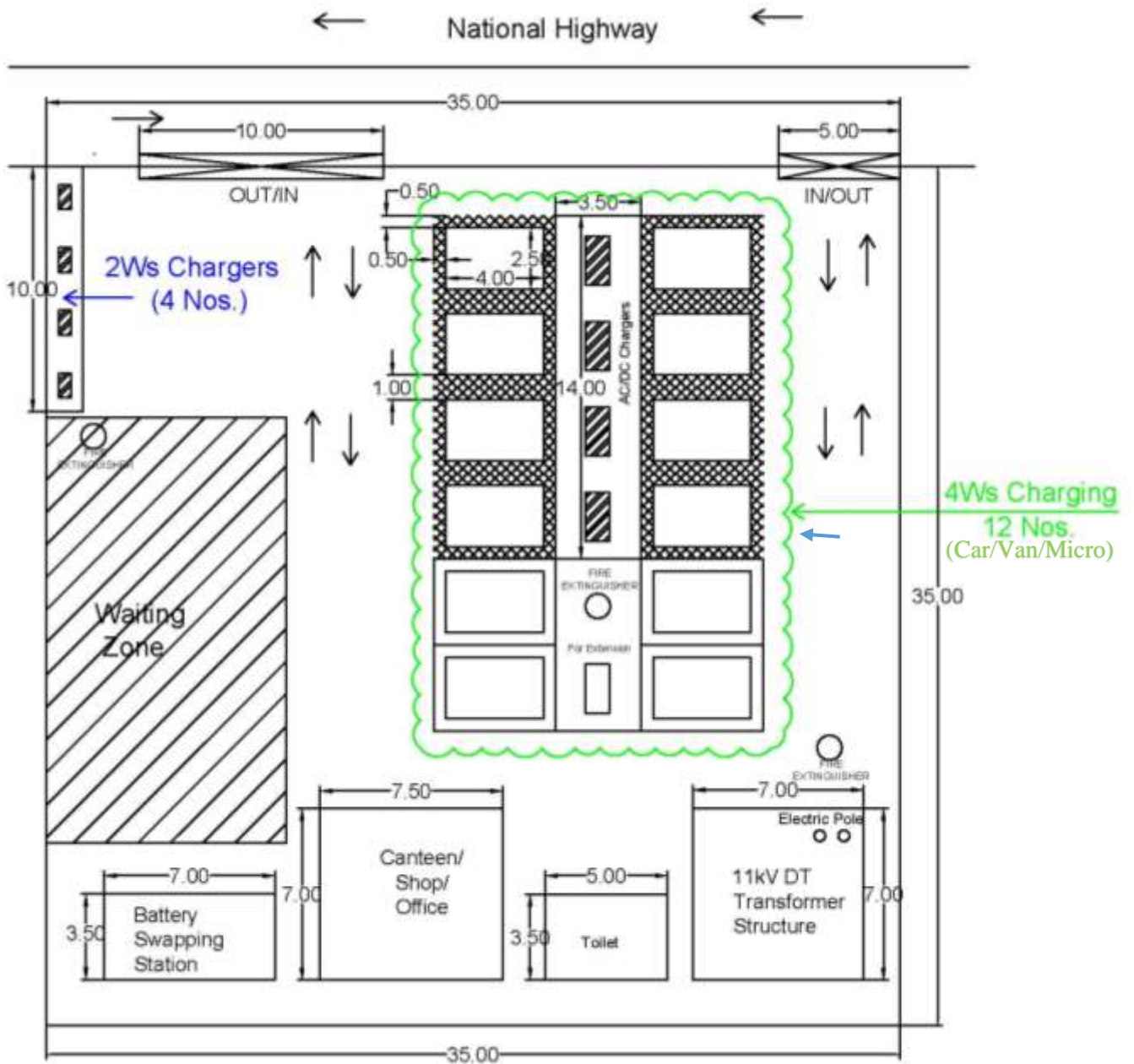
Figure 37: Electrical Single Line Diagram for EVPCI/S for NH, Petrol pump and Buspark. (Category –I)

**4.5.3B. EV Chargers, Layout plan and electrical single line diagram (Category II)**

Type of EV charger to be installed for EVPCI/ Station on the NH of Mountain Area, Petrol pump, Bus park. (Category –II)

<b>SN</b>	<b>EV Segment</b>	<b>Type of EV Charger</b>	<b>Connector and their guns</b>	<b>Number of EV Charger per Charging Station</b>
1	e-2Ws	3.3 kW, 16A, 230V	Type 1,2 AC (1/3 CG)	4
2	e-4Ws	60 kW, 200-750V, DCFC	GB/T (1/2 CG)	2
3	e-4Ws	60 kW, 200-750V, DCFC	CCS-2 (1/2 CG)	1
3	e-4Ws	60 kW, 200-750V, DCFC	CHAdEMO (1/2 CG)	1

Layout Plan for EVCS Category-II



EVCS Layout Area (1225 sq.m.) = 2 Ropani 6 Anna 2 Paisa (3 Kattha 12 Dhur)

Figure 38: Layout for EVPCI/ Station for NH, Petrol pump and Buspark. (Category –II)

**Table 52: Coverage Area Calculation for EV PCI/ Station for NH, Petrol pump and Buspark (Category –II)**

SN	Type of EV	No of EV	Size(m)	Area (Sq.m.)
1	Car/Jeep/Micro/Other 4W	8 + 4 (4 spares)	5x3.5	210
2	Motorcycle and Scooter	12	2x2 (each)	48
3	Charging stand Area	1	21x3.5	73.5
<b>TOTAL (1+2+3) =</b>				<b>331.5</b>
4	Waiting space for EV at same time	8	10x17	170
5	Toilet	5 users	3.5x5	17.5
6	Canteen and Others	1	7.5x7	52.5
7	Battery Swapping Station	1	7x3.5	24.5
8	11kV Distribution Transformer Structure	1	7x7	49
9	Vehicle Movement Area + Greenery + Future Extension	1		580
<b>TOTAL (1+2+3+4+5+6+7+8+9) =</b>				<b>1225</b>

Other structures: Fire Extinguisher – 2 Nos.

Ropani-Anna-Paisa-Dam= **2 Ropani 6 Anna 2 Paisa**

Bigha-Katha-Dam= **3 Kattha 12 Dhur**



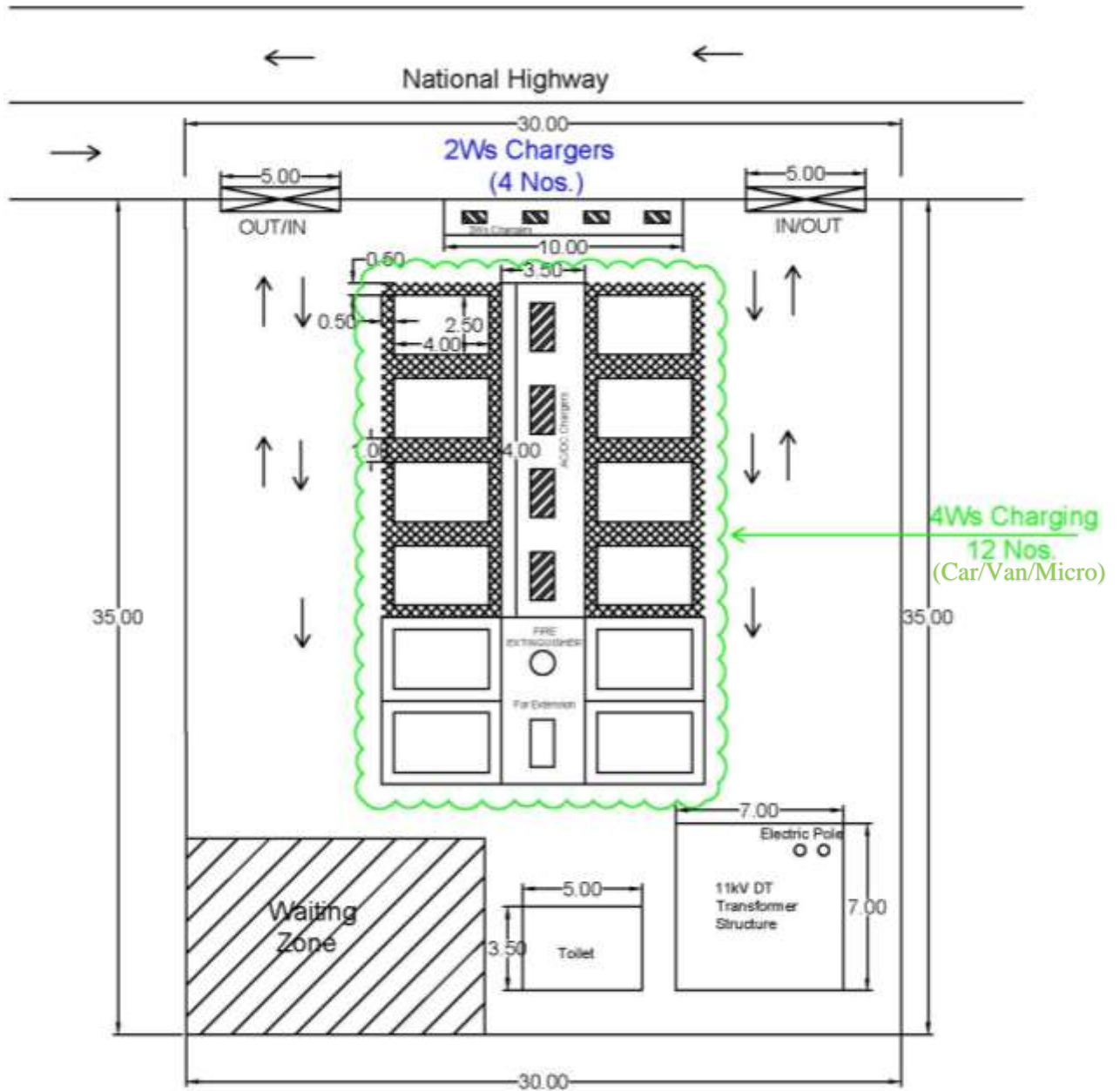
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**4.5.3C. EV Chargers, Layout plan and electrical single line diagram (Category III)**

Type of EV charger to be installed for EVPCI/Station in the housing societies, Malls, Complexes, Restaurants, Hotels office/ work place, workshop and others. (Category –III)

<b>SN</b>	<b>EV Segment</b>	<b>Type of EV Charger</b>	<b>Connector and their guns</b>	<b>Number of EV Charger per Charging Station</b>
1	e-2Ws	3.3 kW, 16A, 230V	Type 1,2 AC (1/3 CG)	4
2	e-4Ws	60 kW, 200-750V, DCFC	GB/T (1/2 CG)	2
3	e-4Ws	60 kW, 200-750V, DCFC	CCS-2 (1/2 CG)	1

Layout Plan for EVCS Category-III



EVCS Layout Area (1050 sq.m.)  
 = 2 ropani 1 Anna (3 Katha 2 Dhur)

Figure 40: Layout for EVPCI/ Station for NH, Petrol pump and Buspark.  
 (Category –III)

**Table 53: Coverage Area Calculation for EV PCI/ Station for NH, Petrol pump and Buspark (Category –III)**

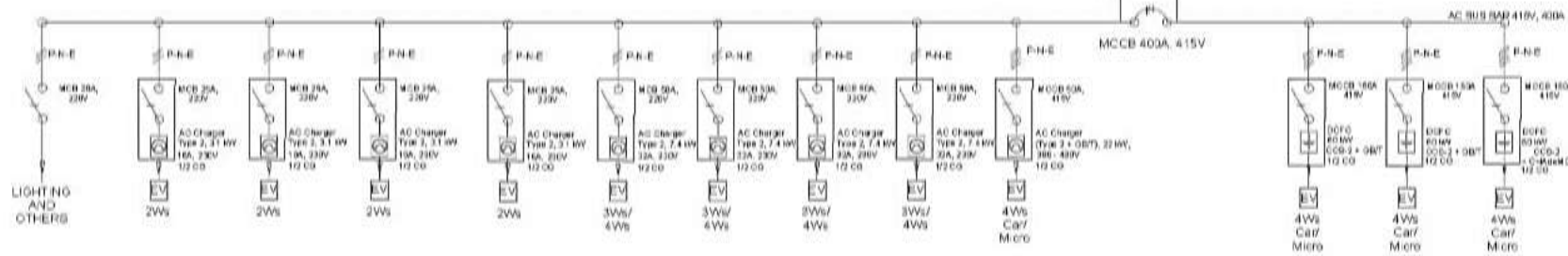
SN	Type of EV	No of EV	Size(m)	Area (Sq.m.)
1	Car/Jeep/Micro/Other 4W	8 + 4 (4 spares)	5x3.5	210
2	Motorcycle and Scooter	12	2x2 (each)	48
3	Charging stand Area	1	21x3.5	73.5
<b>TOTAL (1+2+3) =</b>				<b>331.5</b>
4	Waiting space for EV at same time	8	12x9	108
5	Toilet	5 users	3.5x5	17.5
6	11kV Distribution Transformer Structure	1	7x7	49
7	Vehicle Movement Area + Greenery + Future Extension	1		405
<b>TOTAL (1+2+3+4+5+6+7) =</b>				<b>1050</b>

Other structures: Fire Extinguisher – 1 Nos.

Ropani-Anna-Paisa-Dam= **2 Ropani 1 Anna**

**Load Calculation:**

SN	Type of Charger	EV Segments	Number of Chargers	Load (kW)	
				Calculation (kW)	Total (kW)
1	3.1 kW	e-2Ws	4	=4*3.1/3	4.13
2	22 kW	e-4Ws	1	=1*22/1	22
3	60 kW	e-4Ws	3	=3*60/1	180
4	Lighting				5
<b>Total</b>					<b>211.13 kW</b>



**Figure 41: Electrical Single Line Diagram for EVPCI/S for NHW, Petrol pump and Buspark. (Category –III)**

Note: Flowchart of Installation Procedure (Technical Approval and Electricity Connection) to be followed by the developer/charging station promotor/owner is attached in the Annex IV

**4.5.4. Assessment of ‘Road Gradient’ on the mileage of EVs while accessing the location of the charging infrastructures**

Road gradient, defined as an inclination or decline in the road, plays an important role in the efficiency and performance of electric vehicles (EV). When rising, EVs require an increase in energy production to combat gravity, leading to high battery consumption and a low driving area. This increased demand can also generate extra heat, and potentially affect the battery life and thermal control systems. In contrast, when they sink, regenerative braking systems allow for to recover kinetic energy, improve efficiency and fix the expansion area. However, excessive dependence on regenerative braking can affect the braking performance and thermal stability when vertically descended. As a result, the road gradient should be carefully considered to optimize EV route planning, battery management strategies and efficiency in vehicle design and to ensure reliable operation.

Maximum Gradient as per NRS (Nepal Road Standard)

Design Speed, km/h	20	30	40	60	80	100	120
Maximum Gradient. %	12	10	9	7	6	5	4

A model for road gradient for an electric vehicle (EV) typically accounts for the effect of slope on energy consumption, regenerative braking, and vehicle dynamics. Here’s a general approach:

1. Define Road Gradient (Slope)

$$\text{Gradient (\%)} = \frac{\text{Elevation Change}}{\text{Horizontal Distance}} \times 100$$

$$\text{Incline Angle } (\theta) = \tan^{-1}(\text{Gradient})$$

2. Forces Acting on the EV

Gravitational Force (Fg):  $F_g = mg \sin(\theta)$

Rolling Resistance (Fr):  $F_r = C_r mg \cos(\theta)$

Aerodynamic Drag (Fa):  $F_a = \frac{1}{2} C_d \rho A v^2$

Propulsion Force (Fp): The force required to move the vehicle forward, overcoming the above forces.

3. Power Demand

The power required by the EV to move uphill is:

$$P = F_{\text{total}} * v$$

where:

$$F_{\text{total}} = mg \sin(\theta) + C_r mg \cos(\theta) + \frac{1}{2} C_d \rho A v^2$$

#### 4. Regenerative Braking on Downhill

On a downward slope, regenerative braking can recover energy:

$$P_{\text{regen}} = \eta_{\text{regen}} mg \sin(\theta)v$$

where  $\eta_{\text{regen}}$  is the efficiency of energy recovery.

#### 5. Energy Consumption Model

Total energy consumption for a trip segment EE (Wh/km) can be calculated as:

$$E = \frac{P}{V}$$

Positive for energy consumption (uphill), negative for energy recovery (downhill).

Here's a tabular representation of the road gradient model for an EV:

Parameter	Symbol	Formula / Description	Unit
Road Gradient	G	$\frac{\text{Elevation Change}}{\text{Horizontal Distance}} \times 100$	% (slope)
Incline Angle	$\theta$	$\tan^{-1}(G)$	degrees (°)
Vehicle Mass	m	Given vehicle mass	kg
Gravitational Force	$F_g$	$mg \sin(\theta)$	N (Newton)
Rolling Resistance	$F_r$	$C_r mg \cos(\theta)$	N
Aerodynamic Drag	$F_a$	$\frac{1}{2} C_d \rho A v^2$	N
Total Force	$F_{\text{total}}$	$F_g + F_r + F_a$	N
Power Demand	P	$F_{\text{total}} \times v$	W (Watts)
Regenerative Power	$P_{\text{regen}}$	$\eta_{\text{regen}} mg \sin(\theta)v$	W (Watts)
Energy Consumption	E	$\frac{P}{V}$	Wh/km

Here's a detailed example of an EV road gradient model with sample values:

##### Given Data:

Vehicle Mass (m) = 1500 kg

Gravity (g) = 9.81 m/s<sup>2</sup>

Rolling Resistance Coefficient (C<sub>r</sub>) = 0.01

Aerodynamic Drag Coefficient (C<sub>d</sub>) = 0.3

Air Density (ρ) = 1.225 kg/m<sup>3</sup>

Frontal Area (A) = 2.5 m<sup>2</sup>

Velocity ( $v$ ) = 20 m/s (72 km/h)

Regenerative Efficiency ( $\eta_{\text{regen}}$ ) = 0.7 (70%)

Road Gradient ( $G$ ) = 12% (0.12 slope)

Incline Angle ( $\theta$ ) =  $\tan^{-1}(0.05) \approx 2.86^\circ$

Here is table for **12% Road gradient**:

Parameter	Symbol	Formula	Value	Unit
Road Gradient	G	$\frac{\text{Elevation Change}}{\text{Horizontal Distance}} \times 100$	12%	% (slope)
Incline Angle	$\theta$	$\tan^{-1}(G)$	$6.84^\circ$	degrees ( $^\circ$ )
Gravitational Force	$F_g$	$mg \sin(\theta)$	1766.1	N
Rolling Resistance	$F_r$	$C_r mg \cos(\theta)$	143.7	N
Aerodynamic Drag	$F_a$	$\frac{1}{2} C_d \rho A v^2$	91.88	N
Total Force	$F_{\text{total}}$	$F_g + F_r + F_a$	2001.7	N
Power Demand	P	$F_{\text{total}} \times v$	40.03 kW	W (Watts)
Regenerative Power	$P_{\text{regen}}$	$\eta_{\text{regen}} mg \sin(\theta) v$	22.8 kW	W (Watts)
Energy Consumption	E	$E = \frac{P}{v}$	2001.7	Wh/km

Note:

Uphill (Positive Gradient) → Higher power demand due to gravitational force.

Downhill (Negative Gradient) → Regenerative braking can recover up to 22.8 kW of power.

Total force increases with steeper gradients, requiring more power to maintain speed.

Here is table for **10% Road gradient**:

Parameter	Symbol	Formula	Value	Unit
Road Gradient	G	$\frac{\text{Elevation Change}}{\text{Horizontal Distance}} \times 100$	10%	% (slope)
Incline Angle	$\theta$	$\tan^{-1}(G)$	$5.71^\circ$	degrees ( $^\circ$ )
Gravitational Force	$F_g$	$mg \sin(\theta)$	1471.9	N
Rolling Resistance	$F_r$	$C_r mg \cos(\theta)$	144.7	N
Aerodynamic Drag	$F_a$	$\frac{1}{2} C_d \rho A v^2$	91.88	N
Total Force	$F_{\text{total}}$	$F_g + F_r + F_a$	1708.5	N
Power Demand	P	$F_{\text{total}} \times v$	34.17 kW	W (Watts)
Regenerative Power	$P_{\text{regen}}$	$\eta_{\text{regen}} mg \sin(\theta) v$	19.0 kW	W (Watts)
Energy Consumption	E	$E = \frac{P}{v}$	1708.5	Wh/km

A **10% gradient** requires **34.17 kW** of power, which is lower than the **40.03 kW** required for a **12% gradient**, showing a slight efficiency gain. However, **regenerative braking power also decreases to 19.0 kW** from **22.8 kW** at **12% gradient**.

Here is table for **9% Road gradient**:

Parameter	Symbol	Formula	Value	Unit
Road Gradient	G	$\frac{\text{Elevation Change}}{\text{Horizontal Distance}} \times 100$	9%	% (slope)
Incline Angle	$\theta$	$\tan^{-1}(G)$	5.14°	degrees (°)
Gravitational Force	F <sub>g</sub>	$mg \sin(\theta)$	1324.8	N
Rolling Resistance	F <sub>r</sub>	$C_{rm}mg \cos(\theta)$	145.2	N
Aerodynamic Drag	F <sub>a</sub>	$\frac{1}{2} C_d \rho A v^2$	91.88	N
Total Force	F <sub>total</sub>	$F_g + F_r + F_a$	1561.9	N
Power Demand	P	$F_{total} \times v$	31.24 kW	W (Watts)
Regenerative Power	P <sub>regen</sub>	$\eta_{regen} mg \sin(\theta)v$	17.1 kW	W (Watts)
Energy Consumption	E	$E = \frac{P}{v}$	1561.9	Wh/km

A **9% gradient** requires **31.24 kW** of power, which is lower than the **34.17 kW** required for a **10% gradient**, showing a slight efficiency gain. However, **regenerative braking power also decreases to 17.1 kW** from **19 kW** at **10% gradient**.

Here is table for **7% Road gradient**

Parameter	Symbol	Formula	Value	Unit
Road Gradient	G	$\frac{\text{Elevation Change}}{\text{Horizontal Distance}} \times 100$	7%	% (slope)
Incline Angle	$\theta$	$\tan^{-1}(G)$	4.00°	degrees (°)
Gravitational Force	F <sub>g</sub>	$mg \sin(\theta)$	1030.6	N
Rolling Resistance	F <sub>r</sub>	$C_{rm}mg \cos(\theta)$	146.2	N
Aerodynamic Drag	F <sub>a</sub>	$\frac{1}{2} C_d \rho A v^2$	91.88	N
Total Force	F <sub>total</sub>	$F_g + F_r + F_a$	1268.7	N
Power Demand	P	$F_{total} \times v$	25.37 kW	W (Watts)
Regenerative Power	P <sub>regen</sub>	$\eta_{regen} mg \sin(\theta)v$	13.3 kW	W (Watts)
Energy Consumption	E	$E = \frac{P}{v}$	1268.7	Wh/km

A **7% gradient** requires **25.37 kW** of power, which is lower than the **31.24 kW** required for a **9% gradient**, showing a slight efficiency gain. However, **regenerative braking power also decreases to 13.3 kW from 17.1 kW at 9% gradient.**

Here is table for **6% Road gradient**:

Parameter	Symbol	Formula	Value	Unit
Road Gradient	G	$\frac{\text{Elevation Change}}{\text{Horizontal Distance}} \times 100$	6%	% (slope)
Incline Angle	$\theta$	$\tan^{-1}(G)$	3.43°	degrees (°)
Gravitational Force	F <sub>g</sub>	$mg \sin(\theta)$	883.5	N
Rolling Resistance	F <sub>r</sub>	$C_{rm}mg \cos(\theta)$	146.6	N
Aerodynamic Drag	F <sub>a</sub>	$\frac{1}{2} C_d \rho A v^2$	91.88	N
Total Force	F <sub>total</sub>	$F_g + F_r + F_a$	1122	N
Power Demand	P	$F_{total} \times v$	22.44 kW	W (Watts)
Regenerative Power	P <sub>regen</sub>	$\eta_{regen} mg \sin(\theta)v$	11.5 kW	W (Watts)
Energy Consumption	E	$E = \frac{P}{v}$	1122	Wh/km

A **6% gradient** requires **22.44 kW** of power, which is lower than the **25.37 kW** required for a **7% gradient**, showing a slight efficiency gain. However, **regenerative braking power also decreases to 11.5 kW from 13.3 kW at 7% gradient.**

Here is the table for a **5% road gradient**:

Parameter	Symbol	Formula	Value	Unit
Road Gradient	G	$\frac{\text{Elevation Change}}{\text{Horizontal Distance}} \times 100$	5%	% (slope)
Incline Angle	$\theta$	$\tan^{-1}(G)$	2.86°	degrees (°)
Gravitational Force	F <sub>g</sub>	$mg \sin(\theta)$	736.4	N
Rolling Resistance	F <sub>r</sub>	$C_{rm}mg \cos(\theta)$	147.1	N
Aerodynamic Drag	F <sub>a</sub>	$\frac{1}{2} C_d \rho A v^2$	91.88	N
Total Force	F <sub>total</sub>	$F_g + F_r + F_a$	975.4	N
Power Demand	P	$F_{total} \times v$	19.5 kW	W (Watts)
Regenerative Power	P <sub>regen</sub>	$\eta_{regen} mg \sin(\theta)v$	10.2 kW	W (Watts)
Energy Consumption	E	$E = \frac{P}{v}$	975.4	Wh/km

A **5%** gradient improves efficiency by reducing power demand to **19.5 kW**, compared to **22.44 kW** at 6%. However, this also lowers regenerative braking power to **10.2 kW**, down from **11.5 kW**, limiting energy recovery on descents.

Here is the updated table for a **4% road gradient**:

Parameter	Symbol	Formula	Value	Unit
Road Gradient	G	$\frac{\text{Elevation Change}}{\text{Horizontal Distance}} \times 100$	4%	% (slope)
Incline Angle	$\theta$	$\tan^{-1}(G)$	2.29°	degrees (°)
Gravitational Force	Fg	$mg \sin(\theta)$	589.3	N
Rolling Resistance	Fr	$C_{rmg} \cos(\theta)$	147.5	N
Aerodynamic Drag	Fa	$\frac{1}{2} C_d \rho A v^2$	91.88	N
Total Force	Ftotal	$F_g + F_r + F_a$	828.7	N
Power Demand	P	$F_{total} \times v$	16.57 kW	W (Watts)
Regenerative Power	Pregen	$\eta_{regen} mg \sin(\theta)v$	8.16 kW	W (Watts)
Energy Consumption	E	$E = \frac{P}{V}$	828.7	Wh/km

A 4% gradient enhances efficiency by lowering power demand to **16.57 kW**, outperforming steeper inclines such as 5% (**19.5 kW**), 6% (**22.44 kW**), 7% (**25.37 kW**), 9% (**31.34 kW**), 10% (**34.17 kW**), and 12% (**40.03 kW**). However, regenerative braking also drops to **8.16 kW**, reducing energy recovery potential during descents.

**Table 54: Road Gradient effect on mileage of EVs**

Parameter	4% Gradient	5% Gradient	6% Gradient	7% Gradient	9% Gradient	10% Gradient	12% Gradient	Unit
Incline Angle ( $\theta$ )	2.29°	2.86°	3.43°	4.00°	5.14°	5.71°	6.84°	(°)
Gravitational Force (Fg)	589.3	736.4	883.5	1030.6	1324.8	1471.9	1766.1	N
Rolling Resistance (Fr)	147.5	147.1	146.6	146.2	145.2	144.7	143.7	N
Aerodynamic Drag (Fa)	91.88	91.88	91.88	91.88	91.88	91.88	91.88	N
Total Force (Ftotal)	828.7	975.4	1122	1268.7	1561.9	1708.5	2001.7	N
Power Demand (P)	16.57	19.5	22.44	25.37	31.24	34.17	40.03	kW
Regenerative Power (Pregen)	8.16	10.2	11.5	13.3	17.1	19	22.8	kW

Parameter	4% Gradient	5% Gradient	6% Gradient	7% Gradient	9% Gradient	10% Gradient	12% Gradient	Unit
Energy Consumption (E)	828.7	975.4	1122	1268.7	1561.9	1708.5	2001.7	Wh/km
Energy Consumption (E)	0.829	0.975	1.122	1.269	1.562	1.709	2.002	kWh/km

## Conclusion

Electric vehicles (EV) can be a viable option for Nepal's highways, but their performance is heavily influenced by steep gradients. As our analysis suggests, energy consumption increases rapidly by an inclined more than 6% and reaches 12% gradients approximately 1.2 kWh/km and 2.0 kWh/km. This means that the EVs travel on the mountainous highways of Nepal, such as Tribhuvan and Prithvi Highways require large battery's capacities and strategic charging stations to ensure practical travel area. However, the Hilly terrain region of Nepal also provides an advantage - revived braking, can regain sufficient energy on inferiority, and partly closes high -strength requirements. In order to support extensive adaptation, the country must invest high-power fast chargers along major routes, encourage the use of EVs with efficient hill-climbing capabilities, and develop a sustainable charging infrastructure powered by renewable energy. With these reforms, EV -also can be a viable and environmentally friendly mode of transport on challenging motorways in Nepal.

### 4.5.5. Field Assessment of the Availability of Suitable Land/Location

As part of the Master Plan development for EV charging infrastructure along Nepal's national highways, a comprehensive field visit program was undertaken. The objective was to gain firsthand insights into key on-ground factors such as optimal charging station locations, the capacity of existing electricity infrastructure, land availability, road conditions, and overall installation feasibility. These visits also played a critical role in validating spatial planning data and refining assumptions from the preliminary analysis, ensuring a more accurate and practical approach to network development.

The field visits were carried out by a multidisciplinary technical team comprising experts in transportation planning, electrical engineering, and infrastructure development. The Consultant & Water and Energy Commission Secretariat (WECS) participated at various stages. This collaborative approach ensured a comprehensive evaluation of both technical and administrative feasibility, strengthening the foundation for an effective and well-integrated EV charging network.

The field visits covered selected major national highway, including the East-West Highway (Mahendra Highway), the Mid-Hill Highway, and major north-south routes such as the BP Highway and Prithvi Highway and similarly others too. These Highways were prioritized for their high traffic volume, strategic significance, and potential to anchor Nepal's EV charging network. Over the course of the program, the team traveled more than 6,500 kilometers,

assessing over 200 potential sites across 54 districts. Locations included major towns, highway junctions, tourist hubs, rest areas, fuel stations, and government premises, ensuring a well-distributed and accessible charging infrastructure.

At each identified site, the team conducted a detailed survey, assessing key parameters such as:

- **Electricity Infrastructure:** Availability of grid connections, substation capacity, and potential for upgrades related field visit data is attached in Annex X.
- **Site Suitability:** Land availability, ownership status, and physical feasibility for installation related data is attached in Annex X.
- **Traffic Volume and EV Demand Analysis:** The team assessed the current volume of vehicles passing through each site, evaluated patterns of vehicular movement, and analyzed the potential for electric vehicle (EV) adoption in the area. This included estimating future charging demand based on projected growth in EV usage and local travel trends.
- **Accessibility and Convenience:** Proximity to major roads, safety, and user-friendly facilities.

Photographic documentation, GPS tagging, and preliminary load. This information is being used to populate a GIS-based database that will serve as a planning tool for phase-wise implementation. The collected field data is also being integrated into the Grid Impact Study (GIS) to assess system-level effects of integrating EV loads, especially in areas proposed for heavy vehicle charging stations.

Field visits were essential in validating theoretical frameworks and planning tools, ensuring a practical approach to master planning. This insight gathered will guide site selection, infrastructure design, rollout prioritization, and investment planning for EV charging station. By grounding the master plan in real-world conditions, this approach enhances feasibility, supports effective implementation, and promotes long-term sustainability.

After conducting the initial field visit, it was observed that the proposed location did not fully meet the requirements and objectives of the study. Based on these observations, a decision was made to shift the location to a more suitable site that offers better opportunities for data collection and analysis. The change was necessary to ensure the effectiveness and relevance of the visit in achieving the desired outcomes.

In addition to shifting the proposed location, a new site has also been suggested to broaden the scope of the fieldwork. This new location is expected to provide complementary insights and enhance the overall understanding of the subject matter. We have provided detail of all shifted and new location to our GIS expert to include and prepare in new mapping sheet of the selected locations based on the updated field visit data.

**Table 55: List of Inappropriate Locations**

S. N	ST_CODE	PROVINCE	DISTRICT	ADDRESS	REMARK
1	NH02HS - 50	Koshi	Taplejung	Phungling	Dense forest area
2	NH01HS - 1	Koshi	Jhapa	Kakarbhitta	Insufficient land

S. N	ST_CODE	PROVINCE	DISTRICT	ADDRESS	REMARK
3	NH03S - 124	Koshi	Khotang	Diktel Bazar	built up area
4	NH01HS - 10	Koshi	Morang	Mandirline	Kirat rai samiti area
5	NH02S - 47	Koshi	Ilam	Barbote	cliff land
6	NH03S - 123	Koshi	Khotang	Mahadevsthan	cliff land
7	NH01HS - 2	Koshi	Jhapa	Dhulabari	plotting land area
8	NH01HS - 12	Koshi	Morang	Biratchowk	Insufficient land
9	NH08HS - 43	Koshi	Sunsari	Dharan	Insufficient land
10	NH02S - 46	Koshi	Ilam	Deurali Danda, Suryodaya	football ground
11	NH02S - 49	Koshi	Panchthar	Phidim	Panchthar District Hospital area
12	NH02S - 48	Koshi	Panchthar	Chamaita	Insufficient land & access road for upper house from the proposed area
13	NH01HS - 8	Koshi	Jhapa	Damak Chowk	Insufficient land & access road for upper house from the proposed area
14	NH01S - 143	Madhesh	Saptari	Bhardaha	Insufficient land
15	NH22HS - 153	Madhesh	Dhanusha	Sakuwa mahendranagar Janakpur	Insufficient land & Built up area
16	NH01HS - 20	Madhesh	Sarlahi	Nayaroad	Insufficient land & secondary road
17	NH01HS - 23	Bagmati	Makawanpur	Nawalpur Hetauda	cliff land
18	NH01HS - 29	Lumbini	Rupandehi	Butwal	Road disvision Office area
19	NH01HS - 31	Lumbini	Kapilbastu	Shivaraj	inappropriate land
20	NH01HS - 33	Lumbini	Banke	Khaskusma	Dense forest
21	NH01HS - 34	Lumbini	Banke	Koholpur	Insufficient land
22	NH20S - 52	Madhesh	Siraha	Madar	built up area
23	NH32HS - 56	Madhesh	Sarlahi	Shivsagar Chowk Malangawa	land owner refused to provide land for EVCS
24	NH36HS - 57	Madhesh	Rautahat	Gaur	Bus park area
25	NH41HS - 60	Madhesh	Parsa	Birgunj	Dryport bypass road (Truck bypass area)
26	NH05HS - 68	Lumbini	Rupandehi	Siddharthanagar	Built up area (Hanuman temple)
27	NH51HS - 71	Lumbini	Arghakhanchi	Sandhikharka- Gorusinghe Rd	Santi Bagaicha
28	NH54HS - 72	Lumbini	Dang	Traffic Chowk Ghorahi	Traffic police office ground
29	NH58HS - 75	Lumbini	Banke	Ratna Rajmarg Nepalgunj	Police office ground
30	NH03S - 82	Sudurpashchi m	Dadeldhura	Saule Bazar	cliff land

S. N	ST_CODE	PROVINCE	DISTRICT	ADDRESS	REMARK
31	NH03HS - 83	Sudurpashchim	Doti	Pipalla Bazar Dipayal	No Roadway access to land
32	NH47HS - 86	Lumbini	Palpa	Bartung - Tansen Rd	cliff land
33	NH47S - 88	Gandaki	Syangja	Waling, Bhakunde	Culvert bypass area and land & road level is too different
34	NH47S - 89	Gandaki	Syangja	Putalibazar	Built up area & no access to land
35	NH17S - 93	Gandaki	Tanahu	Belchautara Shuklagandaki	Shree Jana kalyan Sec. School Area
36	NH44S - 97	Gandaki	Gorkha	Laxmi bazar, Gorkha	Built up area (mahalaxmi school area)
37	NH42S - 102	Bagmati	Nuwakot	Ratmate	built up area owner refused to provide land
38	NH42S - 103	Bagmati	Nuwakot	Pasang Lhaamu Highway Bidur	Hotel sunshine land
39	NH15HS - 111	Bagmati	Kabhrepalanchok	Panauti	No Roadway access to land
40	NH34HS - 113	Bagmati	Kabhrepalanchok	Dhulikhel	Too steep land
41	NH13HS - 114	Bagmati	Kabhrepalanchok	Bhakunde Besi	better option we found nearby location
42	NH13S - 118	Bagmati	Sindhuli	Bhiman	Traffic police office
43	NH09S - 136	Koshi	Udayapur	Nepaltar Bazar Udayapur	Insufficient land
44	NH09MS - 133	Koshi	Udayapur	Gaighat	Insufficient land
45	NH20S - 137	Koshi	Udayapur	Sagarmatha Highway, Katari	Insufficient land
46	NH13MS - 158	Bagmati	Sindhuli	Chainpur	Insufficient land
47	NH01MS - 174	Sudurpashchim	Kailali	Lamki Chuha	righ of way and built up area
48	NH18MS - 185	Bagmati	Nuwakot	Kakani	Steep land
49	NH01S - 196	Lumbini	Dang	Lamahi Nagarpalika	Righ of way & Insufficient land
50	NH42MS - 198	Bagmati	Rasuwa	Syapru Besi	cliff land
51	NH03S - 201	Gandaki	Kaski	Badhare, Pokhara	Road and land level is too different
52	NH17HS - 202	Gandaki	Kaski	Adarsha Chwok, Pokhara	Insufficient land

S. N	ST_CODE	PROVINCE	DISTRICT	ADDRESS	REMARK
53	NH03S - 200	Gandaki	Parbat	Kushma	cliff land
54	NH03S - 199	Gandaki	Baglung	Baglung	Built up area

Details of the shifted location, along with the newly suggested location, are presented in the table below. These updates have been made based on the observations and findings from the field visit to ensure alignment with the project objectives and improve the quality of data collection.

**Table 56: New suggested Location of Charging Station along National Highway**

S.N	Location	Station Code	Remarks
1	Koshi Katan	EVCS/161104/NH01 - 15	New
2	Namaste Jharana	EVCS/170706/NH08 - 07	New
3	Mahabodhi Fuel Center(Hile)	EVCS/170603/NH03 - 21	New
4	Khandbari	EVCS/190501/NH08 - 10	New
5	Tumlingtar	EVCS/190509/NH08 - 09	New
6	Inaruwa Bus Park	EVCS/160904/NH01 - 14	New
7	Lahan Bus Park	EVCS/2161001/NH01 - 19	New
8	Koholpur Bus Park	EVCS/5570511/NH01 - 53	New
9	Malangwa Bus Park	EVCS/2191802/NH05 - 21	New
10	Banedugrisain	EVCS/7700910/NH03 - 04	New
11	Beni	EVCS/4430208/NH48 - 1	New
12	Dana	EVCS/4430103/NH48 - 2	New
13	Muktinath	EVCS/4420101/NH48 - 4	New
14	Likhu	EVCS/3280605/NH03 - 15	New
15	Gokarna	EVCS/3270404/UR - 08	New
16	Sankhu BP	EVCS/3270907/UR - 09	New
17	Harisiddhi	EVCS/3250428/UR - 06	New
18	Chapagaun	EVCS/3250210/NH37 - 2	New
19	Bhaisepati	EVCS/3250425/NH37 - 4	New
20	Gongabu BP	EVCS/3270626/NH39 - 08	New
21	Parwanipur	EVCS/2330523/NH41 - 1	New
22	Chandrapur	EVCS/2320302/NH01 - 30	New
23	Rajbiraj Bus Park	EVCS/2151202/NH14 - 2	New
24	Bhaluwang	EVCS/5560801/NH53 - 1	New
25	Sokhutar	EVCS/3200704/NH03 - 17	New
26	Sindhuli BP	EVCS/3200506/NH09 - 14	New
27	Biratnagar Bus Park	EVCS/150211/NH08 - 02	New
28	Phungling	EVCS/110607/NH02 - 6	Shifted

S.N	Location	Station Code	Remarks
29	Dharan	EVCS/160502/NH08 - 05	Shifted
30	Diktel Bus Park	EVCS/1130901/NH03 - 19	Shifted
31	Kakrbhitta Bus Park	EVCS/141406/NH01 - 01	Shifted
32	Damak	EVCS/140607/NH01 - 09	Shifted
33	Dhulabari	EVCS/141410/NH01 - 02	Shifted
34	Birat Chowk	EVCS/150102/NH01 - 11	Shifted
35	Ranke	EVCS/120203/NH02 - 5	Shifted
36	Bhardaha	EVCS/2150910/NH01 - 16	Shifted
37	Gaighat, Udaypur	EVCS/1140713/NH09 - 09	Shifted
38	Nayaroad	EVCS/2191308/NH01 - 29	Shifted
39	Nawalpur Hetauda	EVCS/3310410/NH01 - 35	Shifted
40	Butwal	EVCS/5490109/NH01 - 44	Shifted
41	Phidim Bus Park	EVCS/120602/NH03 - 23	Shifted
42	Shivaraj	EVCS/5500805/NH01 - 48	Shifted
43	Khashkushma	EVCS/5570801/NH01 - 52	Shifted
44	Koholpur	EVCS/5570511/NH01 - 53	Shifted
45	Madar	EVCS/2161617/NH20 - 1	Shifted
46	Malangwa	EVCS/2191804/NH32 - 1	Shifted
47	Gaur	EVCS/2320808/NH36 - 1	Shifted
48	Birgunj	EVCS/2340316/UR - 01	Shifted
49	Sandhikharka Gorusinghe Road	EVCS/5510503/NH09 - 21	Shifted
50	Traffic Chowk, Ghorahi	EVCS/5560514/NH54 - 1	Shifted
51	Ratna Rajmarg Nepalgunj	EVCS/5570705/NH58 - 2	Shifted
52	Saule Bazaar	EVCS/7730305/NH03 - 03	Shifted
53	Bartung-Tansen Road	EVCS/5470904/NH47 - 3	Shifted
54	Waling Bhakunde	EVCS/4391101/NH47 - 6	Shifted
55	Putalibazaar	EVCS/4391014/NH47 - 7	Shifted
56	Belchautara Shuklagandaki	EVCS/4381002/NH17 - 09	Shifted
57	Laxmi Bazar Gorkha	EVCS/4360708/NH44 - 3	Shifted
58	Pasang Lahmu Highway, Bidhur	EVCS/3280205/NH42 - 2	Shifted
59	Panauti	EVCS/3241007/NH15 - 3	Shifted
60	Bhakundesbesi	EVCS/3240902/NH13 - 7	Shifted
61	Bhiman	EVCS/3200509/NH13 - 1	Shifted
62	Nepaltar, Udaypur	EVCS/1140806/NH09 - 11	Shifted
63	Sagarmatha Highway, Katari	EVCS/1140303/NH09 - 12	Shifted
64	Chainpur	EVCS/3200504/NH13 - 3	Shifted

S.N	Location	Station Code	Remarks
65	Lamki Chuha	EVCS/7711102/NH01 - 58	Shifted
66	Deupur Road, Lamahi	EVCS/5560605/NH01 - 50	Shifted
67	Syaprubesi	EVCS/3290105/NH42 - 4	Shifted
68	Badhare, Pokhara	EVCS/4400425/NH03 - 13	Shifted
69	Adarsha Chowk, Pokhara	EVCS/4400429/NH17 - 11	Shifted
70	Kushma	EVCS/4440307/NH03 - 12	Shifted
71	Baglung	EVCS/4450202/NH03 - 11	Shifted

Note: The D-card of the field visit for EVCS location has been attached in the Annex XI

## Conclusion

The field survey conducted for the EVCS Masterplan has provided invaluable, firsthand insights essential for the development of a robust and practical electric vehicle charging infrastructure network along Nepal's national highways. Covering more than 200 sites across 54 districts and spanning over 6,500 kilometers, the multidisciplinary assessment enabled detailed evaluation of grid connectivity, land suitability, accessibility, traffic volumes, and installation feasibility. On-ground findings revealed significant constraints at several initially proposed sites, including insufficient land, challenging terrain, and issues related to land ownership and accessibility. Addressing these challenges, the team systematically identified and shifted to alternative locations that are better aligned with both technical requirements and strategic network coverage. By integrating comprehensive field data into GIS-based planning and grid impact analysis, the Masterplan is now firmly grounded in practical realities, ensuring optimal site selection, efficient resource allocation, and phased implementation. This process has greatly enhanced the feasibility, accessibility, and sustainability of the national EVCS network, laying a solid foundation to support Nepal's transition to clean transport and a greener future.

### 4.5.5.1 Questionnaires Survey Output Summary

The questionnaire output summary is shown below:

- EV Owner/User:

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HIGHWAYS FOR ELECTRIC VECHILES (EV)

Summary of Questionnaires Survey for EV Owner/User

Q.1-What type of EV do you use?

N0. of Questionarie Surveys	2W (Bike/Scooty)	3W (Auto Rickshaw/t ampool)	4W (Car)	4W (Micro)	4W (Bus)	4W (Minibus)
Penetration rate %	0	0	33.33	63.89	0	0

Q.2- What are the main reason that you prefer an EV? Choose upto

N0. of Questionarie Surveys	Capital Cost	Running Cost	Environme nt Issues	Intelligent function	Access to Charge Points	Number of Available Charge Points
36	10%	30%	29%	18%	8%	5%

Q-3,What is the main use of your Electric Vehicle? (km)

N0. of Questionarie Surveys	Going to work on weekends	Drive to public transport	Around town during the day	For Trips	Only a few times per week	Only weekends	Others
36	12.82%	2.56%	33.33%	48.71%	0%	0%	2.56%

Q.4, What is your average mileage of your EV per kWh (unit per km)

No opinion

Q.5-Do you have home charger?

N0. of Questionarie Surveys	Yes	No
Total	72.22%	19.44%

Q.6-What type of charger do you use to charge your EV?

N0. of Questionarie Surveys	Type A (1kW-3kW, AC)	Type B (7kW-22kW, AC)	Type C (20kW - 60kW, DC)
36	13.88%	8.33%	77.78%

Q.7-What type of charging connector do you use to charge your EV?

N0. of Questionarie Surveys	GB/T	CHaEdeM O	CCS	Tesla	Others
36	69.44%	2.78%	305.56%	0	0

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Summary of Questionnaires Survey for EV Owner/User

Q.8-Do you think there are enough charging points?

N0. of Questionarie Surveys	Yes	No
36	55.56%	44.44%

Q.9-How often do you charge your EV?

S.N	Everyday	few times a week	Once a month	few times a month
36	86.11%	122.22%	0	2.77%

Q.10-How long have you been using an EV?

S.N	1 year	2 year	3 year	4 years+
36	80.55%	13.88%	2.77%	2.77%

Q.11-Where do you typically charge your EV?

S.N	Home	Work place/Office	Public Charging Station	Others
36	46.93%	4.08%	42.85%	6.12%

Q.12-Do you think EV are well popular to the public?

S.N	Yes	No
36	97.22%	2.77%

Q.13-Why do you prefer DC fast

a) For Time saving (100%)

Q. 14-Which National Highways of Nepal have you travelled?

No opinion

Q. 15 In ypur opinion, how many distance should be be a one EV Charging station

S.N	25km	75km	100km	50km
36	2.77%	2.77%	36.11%	58.33%

Q. 16 In ypur opinion, how many distance should be be a one EV

S.N	2km	3km	4km	5km
36	8.33%	13.88%	22.22%	55.55%

## Conclusion

The survey of 36 EV owners in Nepal indicates that four-wheel cars dominate electric vehicle usage, driven largely by lower running costs and environmental awareness. Most users charge their vehicles daily, primarily at home or public charging stations, with a preference for DC fast chargers due to their time efficiency. While over half of the respondents consider the current charging infrastructure adequate, nearly half see significant room for improvement, suggesting that EV charging stations should be installed every 50 km along highways and every

5 km within urban areas. The market remains young, with most users having less than two years of experience, yet there is strong optimism regarding the future popularity and adoption of EVs. To sustain this growth, Nepal should prioritize expanding fast-charging networks, standardizing charging connectors, and promoting a wider variety of EV types.

- EVCS owner/User:

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Summary of Questionnaires Survey for EVCS Owner/User

Q-1. What type of EV Charging station you have installed? NHW/Urban Area?

No. of Questionnaire survey	Public Charging Station	Semipublic Charging station	Yes=1 No=0	
			Private Charging station	If any others
37	2.70%	0	94.59%	2.70%

Q-2. What type of EV Chargers you installed in your EV Charging station?

No. of Questionnaire survey	AC, Type - 2	DCFC, GB/T(Kw)			
		30	40	60	80
37		21.12%	52.11%	12.68%	14.09%

DCFC, CCS-1	DCFC, CCS-2 (Kw)				DCFC, CHAdeMO	DCFC, Tesla	CCS-2 & GBT
	30	40	60	80			
	64.58%	27.08%	2.08%	4.16%	0	0	2.08%

Q-3- What type and how many of EV, you have charged/Penetration in your EV Charging station every day?

No. of Questionnaire survey	Car	Microbus	Van, Pickup	Minibus	Bus
37	14.28%	79.88%	0	0	5.83%

Q-4- How many charging cost you collect from EV Users /kWh or unit?

No. of Questionnaire	NRs ..... Kwh or unit.			
	30	40	60	80
Avrg rate/ 1%	2.30%	1.66%	7.50%	20%
Avrg rate/kwh	29.48	18.54	17.08	11.56

Q-5- What are the expenditure for operation and maintenance of EV Charging station/per months?

No. of Questionnaire	NRs .....			
	30 kw	40kw	60kw	80kw
Avrg rate (Rs)	49090.9	300135.2	86875	90000

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Summary of Questionnaires Survey for EVCS Owner/User

Q.6- Are you interested to say something about per kWh /unit rate or Tariff for EV Charging station fixed by NEA/ERC is sufficient for recovery the capital, operation and maintenance of EV Charging Station?

No. of Questionnaire survey	If yes, give opinions	If no, give opinions per 1%
Avrg battery charging rate / 1%		6.32
30 kw battery charging rate/unit (kwh)		21.07
40 kw battery charging rate/unit (kwh)		15.8
60 kw battery charging rate/unit (kwh)		10.53
80 kw battery charging rate/unit (kwh)		7.9

Q. 7-What type of problem are you facing to operate the EV Charging Station?

No. of Questionnaire survey	Not sufficient EV Vehicle flow in the EV Charging station	EV charger has not properly work	Power supply cut-off time to time	EV charging station has not own mobile apps for proper information of EV Owners/ Users.	If any others
	11	7	27	24	

Sufficient = 18.91% 72.97% 64.86%  
insufficient =100%-29.72%=70.27%

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Summary of Questionnaires Survey for EVCS Owner/User

Q.8- What type of solution you are feeling to solve the problem of EV Charging Station?

No. of Questionnaire survey	Dedicated feeder power supply is needed	EV charger compulsory link with mobile apps for proper information of EV Owners/ Users	Every 25 to 100 km distance should have one EVCS on the NHW.	Every 3 to 5 km distance should have one EVCS in the Urban area.	If any others opinions
	31	31	30	13	0
	83.78%	83.78%	81.08%	35.13%	0

Q.9- In your opinion Common type of Charging Station fit for all Company vehicles is beneficial?

No. of Questionnaire survey	Yes	No
37	37	0
	100%	0%

Q.10- How the Charging Station can be made common so that vehicles from many company can be charged?

No. of Questionnaire survey	To need change in socket of charging gun	To need change in common type of paying apps	Both a & b
37	37	37	37
	100%	100%	100%

## Conclusion

The existing EV charging infrastructure in Nepal is predominantly composed of private charging stations, mainly serving electric minibuses and cars, with AC Type-2 and DC fast chargers being the most common. Despite increasing EV adoption, challenges such as low vehicle flow, unreliable power supply, and the absence of integrated mobile applications impede efficient operation and user convenience. Additionally, the current tariff rates set by NEA are often perceived as insufficient to cover operational costs, which discourages investment in charging infrastructure. To address these issues and support sustainable growth,

Nepal must expand public charging stations along highways and in urban centers, ensure dedicated and stable power supply for charging facilities, implement mobile app integration for seamless user experience, and standardize connectors and payment systems to enhance interoperability across networks.

- EV Suppliers:

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Summary of Questionnaires survey for EV suppliers

Company Name	Vehicle Type	Brand	Model	Peak Power	Peak/Rate d Power	Battery	Millage per km	No. of Qty.	Country of Origin
<b>Car</b>									
Sipradi Trading Pvt. Ltd., Kathmandu	Car	TATA	Tigor Xpress-T EV XM	55kW	25kW	26kWh 75Ah	315 km/h	32	India
Automobiles Hospital Pvt. Ltd., Kathmandu	Car		FH772150L M7		7.5kW	150Ah	440km	2	China
Automobiles Hospital Pvt. Ltd., Kathmandu	Car		FH772150L V7		7.5kW	150Ah	315-421km	2	China
Autohost Pvt. Ltd., Kathmandu	Car		FH772150L V7		7.5kW	234Ah	160km/h	4	China
Autohost Pvt. Ltd., Kathmandu	Car		FH772150L M7	15kW	7.5kW	234Ah	160km/h	16	China
Autohost Pvt. Ltd., Kathmandu	Car		FH772150L V7	15kW	7.5kW	234Ah	440km	4	China
Bajra & Bajracharya Enterprises, Lalitpur	Car		G-X8	15kW	7.5kW	7.5kWh 100Ah	80-150 km	4	China
C.G. Motors Pvt.Ltd., Lalitpur	Car	Neta	Neta V	70kW	30kW	350.4V 72kWh	260 Km	2	China
Agni Energy Pvt. Ltd., Thapathali	Car	e VERITC	D6		30.5kW		520KM	16	India
Agni Energy Pvt. Ltd., Thapathali	Car		E20 Plus P4		19kW		110km	8	India
Agni Energy Pvt. Ltd., Thapathali	Car		E20 Plus P6		19kW		110km	6	India
Agni Energy Pvt. Ltd., Thapathali	Van		E-Supro		25kW		115km	5	India
Agni Energy Pvt. Ltd., Thapathali	Car	e VERITC	D6		30.5kW		520KM	6	India
Agni Energy Pvt. Ltd., Thapathali	Car		E20 Plus P4		19kW		321.9-482.8km	16	India
<b>Micro-Bus</b>									
C.G. Motors Pvt.Ltd., Lalitpur	Mini Van		X30LEV	60kW	30kW	88V 41.86kWh	6.21km	3	China
Cimex Inc. Pvt. Ltd., Kathmandu	Mini Van	BYD	M3	100kW	35kW	50.3kWh	300km	11	China
Cimex Inc. Pvt. Ltd., Kathmandu	Mini Van	BYD	T3	100kW	35kW	50.3kWh	300km	2	China
APS Trade Linke Pvt. Ltd.	Mini Van		8 Seater Shuttle Bus		5kW	48V	40km	1	India
N.E.V. Nepal Pvt. Ltd., Kathmandu	Micro Bus		EC36	60kW	30kW	2kWh 125A	300km	56	China
Shaurya Automobiles Pvt. Ltd., Kathmandu	Van		GXA5030X XYBEV8	60kW			440km	1	China
Shaurya Automobiles Pvt. Ltd., Kathmandu	Van		GXA5035X XYBEV	60kW			440km	1	China

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Summary of Questionnaires survey for EV suppliers

Company Name	Vehicle Type	Brand	Model	Peak Power	Peak/Rate d Power	Battery	Millage per km	No. of Qty.	Country of Origin
Sanskriti, Paryatan tatha Nagarik Uddyayan Mantralaya, Dakshin Asia Paryatan Purbhadhar Bikash Aayojana	Mini Van	BYD	MPV T3	100kW		50.3kWh	300km	14	China
Shree Eco Visionary Pvt. Ltd., Lalitpur	Micro Van		M70L	60kW	30kW	36V 41.86kWh	220km	2	China
Cimex Inc Pvt. Ltd.	Van							10	
Agni Energy Pvt. Ltd., Lazimpat	Loader							2	
Shree Eco Visionary Pvt. Ltd., Lalitpur	Micro Van		XM06520	80kW	50kW	88V 50.232kWh	453km	2	China
C.G. Motors Pvt. Ltd., Lalitpur	Micro Van		(KYC V5EV	60kW	30kW	41.86 kWh	300km	40	China
M.A.W. Vridhi Commercial Vehicles Pvt. Ltd., Kathmandu	Van	Foton	I Blue	85kW	39kW	150Ah	167km/chr	1	China
C.G. Motors Pvt. Ltd., Lalitpur	Micro Van		KYC V7EV	60kW	32kW	8V 53kWh l	235km	1	China

**Mini-Bus**

Shree Eco Visionary Pvt. Ltd., Lalitpur	Truck		N50	60kW	30kW	336V 41.86kWh	50km/h	3	China
Shree Muskan Industries	Loader							32	
Sipradi Trading Pvt. Ltd.	Truck	TATA	TATA Ace EV	27kW	11.9kW	92.2V 21.3kWh	155km	2	India
C.G. Motors Pvt. Ltd., Lalitpur	Mini Truck	KYC	KYC X5EV	90kW	40kW	55.7kWh 173Ah	300km	1	China
C.G. Motors Pvt. Ltd., Lalitpur	Truck		XM05030 EV (N100 E-Truck)	60kW	30kW	41.86kWh	155km	1	China
MAW Vridhi Commercial Vehicles Pvt. Ltd., Tripureshwor	Mini Bus		Iblue Auto V6	85kW	39kW	335V 50.23kWh 150Ah	195km	30	China
MAW Vridhi Commercial Vehicles Pvt. Ltd., Tripureshwor	Mini Truck		Iblue Auto T1	60kW	30kW	309V 150Ah		8	China
Sipradi Trading Pvt. Ltd.	Container	TATA	ACE EV GRP/Steel	27kW	11.9kW	21.3kWh	155km	10	India
Kushwaha Motors, Birgunj	Cargo Loader		KTLQ	3000W	2200W	180Ah	482.8-804.7km	30	China

WATER AND ENERGY COMMISSION SECRETARIAT  
GOVERNMENT OF NEPAL  
PREPERATION OF MASTER PLAN FOR PUBLIC CHARGING INFRASTRUCTURE (PCI) ON MAJOR NATIONAL HIGHWAYS FOR  
ELECTRIC VECHILES (EV)

Summary of Questionnaires survey for EV suppliers

Company Name	Vehicle Type	Brand	Model	Peak Power	Peak/Rate d Power	Battery	Millage per km	No. of Qty.	Country of Origin
Continental Trading Enterprises Pvt. Ltd., Kathmandu	Minibus	Higer	H5C EV	90kW	50kW	70.47kWh	200km	2	China
<b>Bus</b>									
N.E.V. Nepal Pvt. Ltd., Kathmandu	Bus		CHTC KINWIN		92kW	614.4V 210Ah	200km	2	China
N.E.V. Nepal Pvt. Ltd., Kathmandu	Bus		HKL6600R BEV11		60kW	346.6V 226Ah	275-489km	2	China
N.E.V. Nepal Pvt. Ltd., Kathmandu	Bus		HKL6600R BEV11	110kW	80kW	345.6V 226Ah	275-489km	1	China
Sundar Yatayata Traders Pvt. Ltd., Kathmandu	Bus		LSK6105G EV1	196kW		637.3V 275Ah		1	China
Sundar Yatayata Traders Pvt. Ltd., Kathmandu	Bus		LSK6850G EV1	196kW		463.7V 275Ah		1	China
Sajha Yatayat Sahakari Sanstha Limited	Bus		HYK6851G BEV	165kW	103kW	512V 161.25kWh 315Ah		3	China
Sanskriti, Paryatan tatha Nagarik Uddyam Mantralaya, Dakshin Asia Paryatan Purbhadhar Bikash Aayojana	Bus	BYD	K8	300kW		324kWh	104.6km	5	
Sanskriti, Paryatan tatha Nagarik Uddyam Mantralaya, Dakshin Asia Paryatan Purbhadhar Bikash Aayojana	Bus	BYD	C6	180kW	90kW	135kWh	520km	5	China
Sundar Traders Pvt. Ltd., Kathmandu	Bus		BX9M-RHD-I	200kW	145kW	175kWh		2	India
N.E.V. Nepal Pvt. Ltd., Kathmandu	Bus	KINWIN	HYK6851G BEV	165kW	103kW	121.1kWh		2	China
Gadgets & Gizmos Traders Pvt. Ltd., Kathmandu	Bus	Skywell	NJL6822B EV1	150kW	80kW	169kWh		1	China

## Conclusion

### EV Suppliers:

The survey of EV suppliers in Nepal reveals a diverse and rapidly growing market featuring cars, vans, buses, trucks, and loaders, primarily imported from Chinese and Indian manufacturers such as BYD and TATA. Vehicle specifications vary widely in terms of power, battery capacity, and driving range, underscoring the necessity for a versatile and adaptable charging infrastructure. Given Nepal's challenging terrain and varied vehicle types, the EVCS master plan should emphasize strategically placed fast and slow chargers tailored to different

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vehicle classes and operational needs. Building strong collaborations with key suppliers and focusing on commercial EV fleets will be essential to developing a reliable, accessible, and cost-effective charging network that supports Nepal’s transition to sustainable transportation and reduces dependence on fossil fuels.

#### **4.5.6 Assessment of Land Availability and Use Modalities for EV Charging Stations**

##### **4.5.6A Assessment of Suitable Land Availability**

A detailed assessment was undertaken to evaluate the availability and suitability of land for the development of electric vehicle (EV) charging stations across strategic locations in Nepal. The evaluation considered both urban and highway contexts, prioritizing areas with high vehicular density, traffic volume, and logistical significance.

Publicly owned land—including spaces under the jurisdiction of municipalities, transport departments, and other government entities—was identified as a key resource. These include bus terminals, roadside rest areas, government office premises, public parking spaces, and vacant utility land. The selection criteria for suitable locations included accessibility, visibility, proximity to the grid, safety, ease of entry/exit, and expected demand.

Private land parcels, such as those adjacent to commercial complexes, fuel stations, shopping centres, and logistic hubs, were also considered viable under specific partnership models. In addition, highway corridors with consistent vehicular movement were surveyed to identify locations suitable for fast-charging infrastructure, particularly for long-distance transport and freight services.

##### **4.5.6B Modes of Land Use and Leasing for Charging Station Development**

To facilitate the timely and cost-effective establishment of EV charging infrastructure, the report recommends adopting diverse and context-specific land use mechanisms. These include:

- a) Long-Term Public Land Leasing:** Government and municipal authorities may allocate public land on a long-term lease basis through transparent and competitive bidding processes. Lease agreements should include performance benchmarks and timelines for station development and operation.
- b) Public-Private Partnership (PPP) Models:** Under the PPP framework, charging stations may be jointly developed on public land, with capital investment, risk-sharing, and operational responsibilities distributed between public entities and private developers. Revenue-sharing mechanisms or viability gap funding (VGF) can be employed to enhance project feasibility.
- c) Use of Public Spaces Through Concessional Agreements:** Municipalities may designate portions of public parking areas, transport hubs, or sidewalks for the installation of charging units. These spaces can be offered at concessional rates to incentivize private sector participation while ensuring compliance with safety, accessibility, and aesthetic standards.

**d) Leasing of Private Land Through Bilateral Agreements:** For locations not served by public land, private landowners may be engaged through lease or rental agreements. These may be structured to align with commercial viability, ensuring optimal station placement in areas with high charging demand.

**e) Integration with Existing Infrastructure:** Existing commercial and institutional establishments such as fuel stations, malls, and logistics depots can serve as host sites for EV chargers. This co-location strategy reduces land procurement costs and accelerates deployment by leveraging existing amenities and user traffic.

These land-use strategies aim to streamline the rollout of EV charging infrastructure, reduce upfront land acquisition barriers, and promote sustainable public-private collaboration. Institutional support, clear regulatory frameworks, and streamlined approval processes are essential to enable effective implementation of these modalities.

#### 4.5.7. Projection for EVs:

a) Business as Usual Scenario:

The Electric Vehicle and ICE (diesel/petrol/hybrid) Vehicle number is extracted from the data of Department of Custom for the recent 10 fiscal years (i.e. 2014/15 to 2024/25) from the Department's website [www.customs.gov.np](http://www.customs.gov.np). The data is screened for the EVs and ICEs/Hybrid for various vehicle segments namely 2W, 3W, car/jeep/van, microbus, minibus, bus for each year. Then, the annual growth rates of each previous two consecutive years' data of EVs and ICEs/Hybrid is calculated respectively. Finally, the average of those annual growth rates is calculated to project the number of vehicles in the years 2083/84, 2085/86, and 2090/91 considering Phase-1 (0-3 years), Phase-2 (3-6 years), and Phase-3 (6-10 years) respectively. This projected number is then applied to calculate the number of charging points and finally the Electric Vehicle Charging Station number for the three different categories (Category-1, Category-2 and Category-3) is obtained.

The average annual growth rate;

$$G_{avg,t} = \frac{G_1 + G_2 + G_3 + \dots + G_n}{n}$$

Where,

$G_{avg,t}$  = Average Growth Rate for future projection for 't' type vehicle

t = type of vehicle, EV or ICE/hybrid

$G_1, G_2, G_3, \dots, G_n$  = Growth Rate of previous 1, 2, 3, ..., n years

$$(G_n)_t = \left( \frac{V_n - V_{n-1}}{V_n} \right) * 100\%$$

$V_n, V_{n-1}$  = Number of 't' type Vehicles for  $n^{th}$  and  $n-1^{th}$  year

Also,

The EV penetration rate of the years 2083/84, 2085/86, and 2090/91 are calculated by,

$$P_n = \frac{EV_n}{TV_n} * 100\%$$

Where,

$P_n$  = Penetration Rate of the  $n^{th}$  year  
 $EV_n$  = Projected year electric vehicle number  
 $TV_n$  = Projected year total vehicle number

b) Sustainable Development Scenario:

The EVs projection in the sustainable development scenario has been forecasted based on the commitments of the third NDC-3.0 of Nepal. The Major assumptions during the scenario are:

Nepal's NDC-3 sets specific sales targets for Battery Electric Vehicles (BEVs) by 2030 and 2035:

- Private passenger vehicles (2-wheelers + 4-wheelers): 90% by 2030 & 95% by 2035
- Public passenger vehicles (4-wheelers: microbuses, minibuses, buses): 70% by 2030 & 90% by 2035
- Freight & waste collection vehicles: 10% by 2030 & 20% by 2035

To project EV sales growth in line with NDC 3.0, the Compound Annual Growth Rate (CAGR) method is widely used. This method assumes steady, compounded growth over the target period.

$$CAGR = (Ending\ Value / Beginning\ Value)^{1/n} - 1$$

Where:

- Ending Value = Identify ending value (EV)
- Beginning Value = Identify beginning value (EV)
- n = Determine number of periods (n)

c) Net-Zero Emission Scenario:

The net-zero emission scenario has been developed based on the targets of the long-term strategy for net-zero emission. The major considerations within this scenario are:

- All the passenger/ private vehicles shall shift to electricity by 2045
- All the freight vehicles shall shift to electricity by 2045

Therefore, for each vehicle type, the formula will be:

1. Calculate the annual change in the number of EVs:

$$\text{Annual EV Change} = (EVs\ in\ Target\ Year - EVs\ in\ Base\ Year) / (Target\ Year - Base\ Year)$$

where:

$$EVs\ in\ Target\ Year = \text{Total number of vehicles in 2045}$$

$$EVs\ in\ Base\ Year = \text{Number of EVs in 2024}$$

2. Calculate the number of EVs for a given year:

$$EVs\ in\ Year\ X = EVs\ in\ Base\ Year + (Annual\ EV\ Change * (Year\ X - Base\ Year))$$

**Table 57 Projection of EVs**

Vehicle Segment	Annual growth rate %	EV penetration rate - 2025	Total number of EVs - 2025	EV penetration rate - 2030	Total number of EVs - 2030	EV penetration rate - 2035	Total number of EVs - 2035
Business as Usual Scenario							
Buses	32.81	6.42	67	10.95	277	18.05	1144

Vehicle Segment	Annual growth rate %	EV penetration rate - 2025	Total number of EVs - 2025	EV penetration rate - 2030	Total number of EVs - 2030	EV penetration rate - 2035	Total number of EVs - 2035
<b>Minibuses</b>	30.06	34.12	294	42.43	1095	51.2	4076
<b>Microbuses</b>	21.49	60.13	363	62.23	961	64.7	2542
<b>Cars/Van/Jeeps</b>	23.64	20.7	11706	31.35	33821	47.19	97711
<b>Three Wheelers</b>	9.53	69.48	13146	70.06	20726	70.74	32676
<b>Two Wheelers</b>	14.19	6.77	10115	11.42	19643	20.44	38145
<b>NDC 3.0 Scenario</b>							
<b>Buses</b>	32.81	8.84	75	49.39	540	96.21	3894
<b>Minibuses</b>	30.06	39.58	299	75.13	1195	99.73	4779
<b>Microbuses</b>	21.49	64.91	369	84.86	1066	97.03	3079
<b>Cars/Van/Jeeps</b>	23.64	24.99	11752	66.38	34621	91.03	101990
<b>Three Wheelers</b>	9.53	71.88	14566	82.40	38352	91.87	100982
<b>Two Wheelers</b>	14.19	9.25	12750	49.71	78768	64.56	486622
<b>Net-Zero Emission Scenario</b>							
<b>Buses</b>	32.81	4.76	843	29.24	4361	52.82	7880
<b>Minibuses</b>	30.06	10.69	1039	33.02	3206	55.35	5377
<b>Microbuses</b>	21.49	17.50	1100	38.12	2398	58.75	3695
<b>Cars/Van/Jeeps</b>	23.64	14.05	43005	35.54	108773	57.03	174541
<b>Three Wheelers</b>	9.53	72.78	151041	79.59	165163	86.39	179284
<b>Two Wheelers</b>	14.19	5.68	127672	29.26	657370	52.84	1187067

Note: The projection of vehicle segment is attached in Annex-VIII

## Conclusion

EV adoption grows steadily but modestly across all vehicle segments, with cars, three-wheelers, and two-wheelers leading in total numbers by 2035. However, penetration rates remain relatively low, indicating limited progress without stronger policy support or market incentives.

This scenario reflects accelerated EV uptake driven by enhanced climate commitments, resulting in significantly higher penetration rates and EV numbers across all segments. Notably, two-wheelers and three-wheelers show rapid growth, highlighting the impact of targeted policies and infrastructure development.

The Net-Zero Emission scenario envisions a rapid and widespread electrification of the entire vehicle fleet, with penetration rates exceeding 50% or more by 2035 in most segments. This ambitious pathway requires substantial investment and systemic change but is critical for meeting stringent climate targets.

Overall, the analysis underscores that strong policy support and strategic planning are crucial to accelerating EV adoption and developing sufficient charging infrastructure tailored to Nepal's evolving electric vehicle market. The Business as Usual scenario reflects slow, incremental growth, while the NDC 3.0 scenario demonstrates significant acceleration in EV penetration across all vehicle segments. The Net-Zero Emission scenario projects a rapid and widespread shift to electric vehicles, requiring major investments and systemic changes.

However, realizing this vision requires substantial upfront investments in charging infrastructure and coordinated efforts to ensure the system can support rapid electrification while meeting user needs effectively.

#### Demand Calculation

Initially, the daily distance driven (in km) for each vehicle for each segments, i.e. 2W, 3W, car/jeep/van, microbus, minibus, bus, is assumed after the literature review, market study, questionnaire survey, discussion among the team. Then, the average battery capacity in kWh is taken as per the market study and data collected from various vehicle companies. Also, the driving range (in km) when full charged for each vehicle of the above mentioned segments are taken from the market study. These data are used to calculate the daily charging demand of one vehicle of every segments. The formula is,

$$D_j = \left( \frac{DD_j}{DR_j} \right) * BC_j$$

Where,

$D_j$  = Daily charging demand, in kWh, for one vehicle of 'j' segment

$j$  = any one of the segments (2W, 3W, car/jeep/van, microbus, minibus or bus)

$DD_j$  = Assumed Daily distance driven by one vehicle of 'j' segment, in km

$DR_j$  = Driving range in full battery charge of each vehicle of 'j' segment, in km

$BC_j$  = Average battery capacity of each vehicle of 'j' segment, in kWh

**Table 58: Projection of Energy Demand**

Vehicle Segments	Daily kms driven	Battery capacity in kWh	Driving range in km/full charge (Range)	Daily charging demand in kWh	Total daily charging demand in kWh - 2025	Total daily charging demand in kWh - 2030	Total daily charging demand in kWh - 2035
	A	B	C	D=(A/C)*B	E	F	G
<b>Business as Usual Scenario</b>							
Buses	250	161	200	201.25	13488	55722	230198
Minibuses	200	90	150	120	35319	131434	489107
Microbuses	180	60	150	72	26141	69173	183043
Cars/Van/Jeeps	110	51.1	250	22.484	263205	760424	2196939
Three Wheelers	90	7	100	6.3	82818	130571	205860
Two Wheelers	20	2.5	80	0.625	6322	12277	23841
<b>NDC 3.0 Scenario</b>							
Buses	250	161	200	201.25	15077	108696	783639
Minibuses	200	90	150	120	35834	143349	573451
Microbuses	180	60	150	72	26599	76786	221663
Cars/Van/Jeeps	110	51.1	250	22.484	264232	778409	2293135

Vehicle Segments	Daily kms driven	Battery capacity in kWh	Driving range in km/full charge (Range)	Daily charging demand in kWh	Total daily charging demand in kWh - 2025	Total daily charging demand in kWh - 2030	Total daily charging demand in kWh - 2035
	A	B	C	$D=(A/C)*B$	E	F	G
Three Wheelers	90	7	100	6.3	91763	241617	636187
Two Wheelers	20	2.5	80	0.625	7969	49230	304139
<b>Net-Zero Emission Scenario</b>							
Buses	250	161	200	201.25	169596	877709	1585821
Minibuses	200	90	150	120	124660	384960	645260
Microbuses	180	60	150	72	79231	172625	266019
Cars/Van/Jeeps	110	51.1	250	22.484	966917	2445652	3924387
Three Wheelers	90	7	100	6.3	951560	1040525	1129490
Two Wheelers	20	2.5	80	0.625	79795	410856	741917

Under the Business as Usual scenario, the growth in electric vehicle adoption and corresponding daily charging demand progresses steadily but moderately. This reflects current market dynamics and policy frameworks that support gradual electrification. While demand increases across all vehicle segments, the pace remains incremental, underscoring the need for continued but measured investment in charging infrastructure to accommodate future growth.

The NDC 3.0 scenario projects a more accelerated increase in daily charging demand driven by strengthened national climate commitments and enhanced regulatory support. This scenario anticipates significant growth particularly in light and medium-duty vehicles, signaling a shift toward more aggressive electrification. The resulting surge in energy demand necessitates strategic scaling of grid capacity and charging networks to ensure reliable and efficient EV integration.

The Net-Zero Emission scenario envisions a transformative leap in electric vehicle penetration, with daily charging demand rising exponentially across all vehicle segments. This scenario reflects an ambitious transition aligned with stringent decarbonization targets, requiring substantial upgrades to energy infrastructure, including high-capacity charging solutions and smart grid integration. Coordinated policy and industry action will be essential to support this rapid expansion and realize sustainable transportation goals.

**Table 59: Energy Demand Scenario Comparison**

Vehicle Segment	Daily Charging Demand (kWh)	2025 (BAU)	2025 (NDC-3.0)	2025 (NZE)	2030 (BAU)	2030 (NDC-3.0)	2030 (NZE)	2035 (BAU)	2035 (NDC-3.0)	2035 (NZE)
Buses	201.25	13,488	15,077	1,69,596	55,722	1,08,696	8,77,709	2,30,198	7,83,639	15,85,821
Minibuses	120	35,319	35,834	1,24,660	1,31,434	1,43,349	3,84,960	4,89,107	5,73,451	6,45,260
Microbuses	72	26,141	26,599	79,231	69,173	76,786	1,72,625	1,83,043	2,21,663	2,66,019
Cars/Vans/Jeeps	22.484	2,63,205	2,64,232	9,66,917	7,60,424	7,78,409	24,45,652	21,96,939	22,93,135	39,24,387
Three Wheelers	6.3	82,818	91,763	9,51,560	1,30,571	2,41,617	10,40,525	2,05,860	6,36,187	11,29,490
Two Wheelers	0.625	6,322	7,969	79,795	12,277	49,230	4,10,856	23,841	3,04,139	7,41,917
<b>Total (kWh)</b>		<b>4,27,292</b>	<b>4,41,474</b>	<b>23,71,759</b>	<b>11,59,600</b>	<b>13,98,087</b>	<b>53,32,327</b>	<b>33,28,988</b>	<b>48,12,213</b>	<b>82,92,895</b>
<b>Total (MWh)</b>		<b>427</b>	<b>441</b>	<b>2,372</b>	<b>1,160</b>	<b>1,398</b>	<b>5,332</b>	<b>3,329</b>	<b>4,812</b>	<b>8,293</b>
<b>Total (MW)</b>		<b>35.58</b>	<b>36.75</b>	<b>197.67</b>	<b>96.67</b>	<b>116.50</b>	<b>444.33</b>	<b>277.42</b>	<b>401.00</b>	<b>691.08</b>

The table clearly shows a substantial increase in daily charging demand across all vehicle segments from 2025 to 2035, with the Net-Zero Emission (NZE) scenario exhibiting the highest demand, followed by the NDC 3.0 and Business as Usual (BAU) scenarios. Total daily charging demand grows from 427 MWh in 2025 (BAU) to a remarkable 8,293 MWh by 2035 under NZE, highlighting the scale of infrastructure needed. Cars/vans/jeeps and three-wheelers are the largest contributors to this demand, driven by their higher numbers and daily usage. This rapid growth underscores the urgent need for significant investment in charging infrastructure capacity—both in terms of energy (MWh) and power (MW)—to support Nepal’s ambitious EV adoption targets and ensure a reliable, efficient charging network over the next decade.

**Table 60: Annual CO<sub>2</sub> Emissions Avoided by Electric Vehicles**

Vehicle Segment	BAU 2025 ktCO <sub>2</sub> /year	BAU 2030 ktCO <sub>2</sub> /year	BAU 2035 ktCO <sub>2</sub> /year	NDC 3.0 2025 ktCO <sub>2</sub> /year	NDC 3.0 2030 ktCO <sub>2</sub> /year	NDC 3.0 2035 ktCO <sub>2</sub> /year	Net-Zero 2025 ktCO <sub>2</sub> /year	Net-Zero 2030 ktCO <sub>2</sub> /year	Net-Zero 2035 ktCO <sub>2</sub> /year
Buses	3.2	13.4	55.2	3.6	26	187.8	40.7	211	379.4
Minibuses	6.3	23.5	87.4	6.4	25.6	102.4	22.3	68.7	115.3
Microbuses	5.1	13.5	35.8	5.2	15	43.3	15.5	33.8	52
Cars/Vans/Jeeps	32.6	94.2	271.9	32.7	96.5	181.4	119.7	302.4	484.9
Three Wheelers	21.4	33.7	53.1	23.6	89.2	164.4	245.4	268.5	291
Two Wheelers	4.7	9.1	17.7	5.9	37	226	59.3	304	551
<b>Total</b>	<b>73.3</b>	<b>187.4</b>	<b>521.1</b>	<b>77.4</b>	<b>289.3</b>	<b>905.3</b>	<b>502.9</b>	<b>1188.4</b>	<b>1873.6</b>

Note: All figures represent estimated annual CO<sub>2</sub> avoided in thousand tonnes per year.

The detail calculation is present in Annex VIII

The calculation involved

1. Annual Fuel Consumption

Multiply the average kilometers traveled per year by the fuel consumption rate (litres/km) for each vehicle segment.

Formula:

$$\text{Litres/year} = \text{Average km/year} \times \text{Litres/km}$$

## 2. Annual CO<sub>2</sub> Emissions Avoided

Multiply the annual fuel consumption (litres/year) by the emission factor (kg CO<sub>2</sub>/litre) specific to the fuel type (diesel or petrol).

Formula:

$$\text{Annual CO}_2 \text{ avoided (kg/year)} = \text{Litres/year} \times \text{Emission Factor (kg CO}_2\text{/litre)}$$

The above table presents the estimated annual CO<sub>2</sub> emissions avoided (in thousand tonnes per year) across major vehicle segments in Nepal under three scenarios: Business as Usual (BAU), Nationally Determined Contributions (NDC 3.0), and Net-Zero, for the years 2025, 2030, and 2035. These projections illustrate the significant impact of electric vehicle (EV) adoption on reducing greenhouse gas emissions in the transport sector.

### Analysis

**Business as Usual (BAU):** Under the BAU scenario, the total annual CO<sub>2</sub> emissions avoided are projected to increase from 73.3 kt in 2025 to 521.1 kt by 2035, reflecting gradual EV adoption without aggressive policy intervention.

**Nationally Determined Contributions (NDC):** The NDC scenario, aligned with Nepal's climate commitments, projects a more substantial increase, with emissions avoided reaching 905.3 kt by 2035.

**Net-Zero:** The Net-Zero pathway demonstrates the highest potential impact, with annual CO<sub>2</sub> avoided rising dramatically from 502.9 kt in 2025 to 1,873.6 kt in 2035, highlighting the transformative effect of full-scale electrification and decarbonization of the transport sector.

Among all vehicle segments, cars/vans/jeeps and three-wheelers contribute the largest share of emissions avoided, especially under the Net-Zero scenario. This underscores the importance of prioritizing these segments in Nepal's EV adoption strategy.

### Conclusion

These projections clearly demonstrate that accelerated EV adoption, supported by robust policy frameworks and infrastructure investments, can deliver substantial reductions in transport-related CO<sub>2</sub> emissions. Achieving the Net-Zero scenario will require ambitious action but offers the greatest environmental benefit for Nepal's sustainable development goals.

**Table 61: Projection of EVs Charger**

Vehicle Segments	Share of public Charging	Charger Types	Number of chargers - 2025	Number of chargers - 2030	Number of chargers - 2035	No. of Vehicles charged per charging point in 12 Hrs
<b>Business as Usual Scenario</b>						
Buses	90%	120kWDC	5	21	86	12
Minibuses	90%	60kWDC	11	41	153	24
Microbuses	75%	60 kW DC	11	30	79	24
Cars/Van/Jeeps	20%	Type 2AC (30%)	234	676	1954	3

Vehicle Segments	Share of public Charging	Charger Types	Number of chargers - 2025	Number of chargers - 2030	Number of chargers - 2035	No. of Vehicles charged per charging point in 12 Hrs
Cars/Van/Jeeps		60kWDC (70%)	68	197	570	24
Three Wheelers	5%	Single Phase	329	518	817	2
Two Wheelers	10%	Single Phase	506	982	1907	2
<b>NDC 3.0 Scenario</b>						
Buses	90%	120kWDC	6	41	292	12
Minibuses	90%	60kWDC	11	45	179	24
Microbuses	75%	60 kW DC	12	33	96	24
Cars/Van/Jeeps	20%	Type 2AC (30%)	235	692	2040	3
Cars/Van/Jeeps		60kWDC (70%)	69	202	595	24
Three Wheelers	5%	Single Phase	364	959	2525	2
Two Wheelers	10%	Single Phase	637	3938	24331	2
<b>Net-Zero Emission Scenario</b>						
Buses	90%	120kWDC	63	327	591	12
Minibuses	90%	60kWDC	39	120	202	24
Microbuses	75%	60 kW DC	34	75	115	24
Cars/Van/Jeeps	20%	Type 2AC (30%)	860	2175	3491	3
Cars/Van/Jeeps		60kWDC (70%)	251	635	1018	24
Three Wheelers	5%	Single Phase	3776	4129	4482	2
Two Wheelers	10%	Single Phase	6384	32868	59353	2

**Table 62: Charger requirement for Electric Vehicles**

Vehicle Type	Charger requirements
Two Wheelers	Single Phase 15 A (3.3 kW)
Three Wheelers	Single Phase 15 A (7.4 kW)
Cars/Van/ Jeeps	Type-2 AC (22 kW)
Cars/Van/ Jeeps	CCS 2.0 (60 kW)
Microbuses	Type-2 AC (22 kW) or DC (60 kW), GBT
Minibuses	DC (120 kW) GBT
Buses	DC (120 kW) GBT

In Business as Usual Scenario Charger deployment grows steadily but remains modest, with relatively high vehicle-to-charger ratios for fast-charging points, especially for buses and commercial vehicles. This limited rollout could constrain convenience and operational flexibility as EV adoption rises, highlighting the need for expanded infrastructure to avoid bottlenecks

In NDC 3.0 Scenario Charger numbers increase more robustly, particularly for two- and three-wheelers, reflecting higher EV penetration and the impact of stronger policies. The mix of AC and DC chargers supports a broader range of vehicles, but continued investment is needed to maintain low vehicle-to-charger ratios and meet growing demand efficiently

In Net-Zero Emission Scenario a transformative expansion in public charging infrastructure is projected, especially for high-volume segments like two- and three-wheelers. The scenario achieves much lower vehicle-to-charger ratios, supporting mass-market EV adoption and minimizing wait times. Success here depends on sustained investment and a diversified, well-planned charging network with both fast and slow charger options

#### 4.5.8. Optimal Location Selection

##### 4.5.8.1. Demand Model Analysis

The accelerating adoption of electric vehicles (EVs) is reshaping the transportation landscape, driving the urgent need for a strategically deployed network of electric vehicle charging stations (EVCS). Accurate demand forecasting and optimal site selection are critical to ensure that infrastructure keeps pace with market growth and user needs. This analysis applies a systematic, data-driven approach to forecast demand and identify priority locations for EVCS, with a particular focus on national highways and urban corridors. Rationale for BAU Scenario as the Analytical Baseline

For robust demand modeling, the Business as Usual (BAU) scenario is adopted as the reference case. The BAU scenario is particularly well-suited for this analysis because it reflects prevailing market trends, policy environments, and consumer behavior without the influence of new interventions or accelerated policy measures. By projecting forward from historical data and current growth rates, the BAU scenario provides a realistic baseline against which the impacts of future policies or investments can be measured.

Demand for EVCS was estimated using an energy balance formula, relating the total energy demand from EVs to the supply capacity of public charging stations:

$$C_i = \frac{N \cdot e \cdot d \cdot R_i}{p_i \cdot t_c}$$

Where,

$C_i$  = No's of EV charger

$N$  = Nos. of electric vehicles

$e$  = energy consumption of an electric vehicle (kWh/km)

$d$  = daily driven distance (km)

$R_i$  = percentage of consumed energy recharged at charging station

$p_i$  = power of charging station (kW)

tc= average charging time

n = service life

**Table 63: Comparison Table of Optimal Location**

Type of Charger in Charging Station	Share of public Charging % of total Evs	No of EVs sharing in EVCS as per 2025	EVC S no in 2025	No of EVs sharing in EVCS as per 2030	EVCS no in 2030	No of EVs sharing in EVCS as per 2035	EVCS no in 2035
2W-2.5 kW	10	1012	4	1964	8	3815	11
3W-7 kW	5	657	10	1036	16	1634	16
4W-22 kW	20	702	48	2029	138	5863	133
4W-60 kW	20	1639	20	4735	59	13680	43
4W-60 kW	75	218	17	721	58	1907	51
4W-60 kW	90	283	38	986	66	3668	163
Bus-120 kW	90	60	7	249	28	1029	38
Total Excluding 2W&3W			130		211		428

The detail Calculation of Optimal is Present in Annex -VIII

Economic feasibility was assessed by comparing marginal yearly profit against annualized investment costs, ensuring that infrastructure investments are both necessary and sustainable.

#### 4.5.8.2. GIS-MCDM Analysis and Optimal Location Identification

Geographic Information Systems (GIS) and Multi-Criteria Decision Making (MCDM) techniques were used to map and analyze EVCS sites, ensuring that station placement maximizes accessibility, utilization, and equity—especially for underserved regions. From the final output we have got 424 locations from GIS-MCDM method.

Year	Demand-Model EVCS Needed	Total EVCS as per Demand Model	GIS-MCDM EVCS Identified	Total EVCS as per GIS-MCDM
2025	130	428	168	424
2030	81		123	
2035	217		133	

#### Conclusion

A comparative assessment of EV charging station (EVCS) planning using the Demand-Model and GIS-MCDM approaches reveals important insights for Nepal's EVCS Master Plan. In 2025, the Demand-Model projected a need for 130 new stations (totaling 428), while the GIS-MCDM method identified 168 optimal sites (totaling 424). By 2030 and 2035, the Demand-Model forecasted higher requirements (81 and 217 stations) compared to GIS-MCDM's 123 and 133 sites, respectively. These differences highlight the strengths of each method: The Demand-Model focuses on meeting projected EV growth and charging demand, while GIS-MCDM optimizes spatial distribution and site suitability. For Nepal's evolving EV landscape, GIS-MCDM offers a more location-efficient, data-driven framework for phased deployment, but integrating both approaches is recommended to ensure both demand fulfillment and spatial efficiency in national EVCS planning.

## 4.6 ROLLOUT PRIORITY PLAN FOR EV PUBLIC CHARGING INFRASTRUCTURE

### 4.6.1. Role of Three Tier of Government as Well as Different Institution and Agencies for EVCS Development

**Table 64 : Role of three tier of government for EVCS Development**

INSTITUTIONAL PROVISION	RECOMMENDATION
<b>Government Sector</b>	
1. Federal Government	a. Policy Formation & National Planning <ul style="list-style-type: none"> <li>▪ Ministry of Energy, Water Resources and Irrigation (MoEWRI)</li> <li>▪ Ministry of Physical Infrastructure and Transport (MoPIT)</li> <li>▪ Ministry of Forests and Environment (MoFE)</li> <li>▪ Ministry of Finance (MoF) – for subsidies, tax rebates</li> </ul> b. Regulatory & Licensing Authorities <ul style="list-style-type: none"> <li>▪ Nepal Electricity Authority (NEA) – Main body responsible for electricity supply, installation, and operation of EV charging infrastructure.</li> <li>▪ Department of Transport Management (DoTM) – Registration and regulation of electric vehicles.</li> </ul> c. Standardization & Quality Assurance <ul style="list-style-type: none"> <li>▪ Nepal Bureau of Standards and Metrology (NBSM)</li> <li>▪ Alternative Energy Promotion Centre (AEPC)</li> </ul>
2. Provincial Government	a. Regional Infrastructure Development <ul style="list-style-type: none"> <li>▪ Work on integrating EVCS with provincial transport plans.</li> <li>▪ Coordination with local governments for suitable sites and utilities.</li> </ul> b. Support Programs & Incentives <ul style="list-style-type: none"> <li>▪ Provide regional incentives or facilitate public-private partnerships (PPPs).</li> <li>▪ Monitoring implementation within provinces.</li> </ul> c. Relevant Bodies <ul style="list-style-type: none"> <li>▪ Provincial Ministry of Physical Infrastructure</li> <li>▪ Provincial Transport Management Offices</li> </ul>
3. Local Government (Municipalities/ Rural Municipalities)	a. On-ground Implementation & Permits <ul style="list-style-type: none"> <li>▪ Allocate land and space for EVCS.</li> <li>▪ Provide building and construction permits.</li> </ul> b. Public Awareness & Stakeholder Coordination <ul style="list-style-type: none"> <li>▪ Promote EV usage among the community.</li> <li>▪ Facilitate collaboration between private investors, NEA, and communities.</li> </ul> Examples: <ul style="list-style-type: none"> <li>▪ Kathmandu Metropolitan City, Lalitpur Metropolitan City – have shown interest in sustainable mobility.</li> </ul>

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**Key Institutions and Agencies Supporting EVCS Development**

<b>INSTITUTION/AGENCY</b>	<b>ROLE</b>
Nepal Electricity Authority (NEA)	Primary developer and operator of public EV charging stations across Nepal.
Alternative Energy Promotion Centre (AEPC)	Promotes renewable energy technologies and may support solar-powered EVCS in remote areas.
Department of Transport Management (DoTM)	Registration, inspection, and standards for EVs.
Nepal Bureau of Standards and Metrology (NBSM)	Develops technical standards and certifications for EVCS components.
Investment Board Nepal (IBN)	Facilitates large-scale infrastructure projects including EV infrastructure.
National Planning Commission (NPC)	Integrates EV goals in national development plans.
Local Development Training Academy (LDTA)	Capacity building for local governments in implementing clean mobility solutions.
Private Sector and NGOs	Companies like BYD, Tata, Hyundai, and local businesses are investing in charging stations; NGOs promote green mobility awareness.

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#### **4.6.2 Priority for Rollout of Ev Public Charging Infrastructure of National Highway from SNH 2020/2021**

- **Phase I (1-3 Years): (2025-2027)**

Based on multi-criteria ranking using the Analytic Hierarchy Process (AHP), major National Highways were selected. Considering all major cities including Provinces, District Headquarters, Metropolitan, and Sub-metropolitan areas, selected National Highways were marked with consideration for optimal placement of EVs PCI. The distance between charging stations is strategically set at 50-100 km, ensuring maximum network efficiency, regional accessibility, and operational feasibility. In this phase 168 location has been classified on the basis of above criteria. The status of the national highways included in this phase are detailed in Annex XII.

- **Phase II (3-6 Years): (2028-2030)**

From the Analytic Hierarchy Process (AHP), major National Highways have been selected to prioritize EVPCI deployment, ensuring strategic coverage. By considering all major cities, District Headquarters, Municipalities, and Rural Municipalities, optimum selection for EVs PCI locations is ensured. The distance between two charging stations is taken less than 50 km marks selected National Highways. In this phase 123 location has been classified on the basis of above criteria. The status of the national highways included in this phase are detailed in Annex XII.

- **Phase III (6-10 Years): (2031-2035)**

In this Phase strategically expands EV charging infrastructure to Nepal's more remote areas, bridging coverage gaps in the network to promote nationwide EV adoption. Predominantly encompassing major national highways that are currently gravel or earthen roads, with many still under construction, this phase addresses the unique challenges of these less-developed regions. In this phase, 133 locations have been classified on the basis of above criteria. The status of the national highways is detailed in Annex XII.

Table 65: Phase wise categorization of Location of EVCS

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
<b>Phase-I</b>								
1	EVCS/150211/NH0 8 - 02	Koshi (Morang)	Biratnagar Metropolitan - 11	Biratnagar Bus Park	26.450586	87.275388	248, 249, 225, 327, 245, 326	Bakhari6
2	EVCS/150203/NH0 8 - 03	Koshi (Morang)	Biratnagar Metropolitan - 3	Biratnagar	26.476872	87.276919	743, 2420, 1468, 122, 2419, 1826, 129, 2421	Kanchanba ri6
3	EVCS/140308/NH0 4 - 1	Koshi (Jhapa)	Bhadrapur Municipality - 8	Bhadrapur	26.551508	88.089778	57, 23, 132, 131, 4	Bhadrapur4
4	EVCS/140310/NH0 2 - 2	Koshi (Jhapa)	Bhadrapur Municipality - 10	Bhadrapur	26.576251	88.067005	242, 243	chandragad hi6
5	EVCS/140610/NH7 8 - 1	Koshi (Jhapa)	Damak Municipality - 10	Damak	26.59394	87.645086	291, 292, 128, 127. 201, 209	Damak19
6	EVCS/160903/NH0 1 - 13	Koshi (Sunsari)	Inaruwa Municipality - 3	Inaruwa	26.61239	87.152694	1895, 1894, 0, 695	Inaruwa3
7	EVCS/141406/NH0 1 - 01	Koshi (Jhapa)	Mechinagar Municipality - 6	Kakarbhitta Bus Station	26.647426	88.156248	1590, 146, 147, 40, 100016, 39	Nakakband a8
8	EVCS/141511/NH0 1 - 07	Koshi (Jhapa)	Shivasataxi Municipality - 11	Shivasatakshi	26.647548	87.82096	-	-
9	EVCS/160105/NH0 7 - 1	Koshi (Sunsari)	Barah Municipality - 5	Bharaul	26.752683	87.180964	1735, 1734, 397, 18, 1762	Bharaul4
10	EVCS/160506/NH0 9 - 05	Koshi (Sunsari)	Dharan Sub- Metropolitan - 6	Dharan	26.771679	87.312701	227, 349	Bajhagara3

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
11	EVCS/1140713/NH 09 - 09	Koshi (Udayapur)	Triyuga Municipality - 13	Gaighat Baruwa Bus Park	26.789446	86.710857	50, 51, 120	Gaighat5k a
12	EVCS/160502/NH0 8 - 05	Koshi (Sunsari)	Dharan Sub- Metropolitan - 2	Dharan Bus Park	26.811782	87.284923	7, 15, 14, 56, 24, 9, 15	Dharan6
13	EVCS/1140109/NH 09 - 07	Koshi (Udayapur)	Belaka Municipality - 9	Thoksila	26.81572	87.06448	35, 192	Thoksila2k a
14	EVCS/1140707/NH 09 - 10	Koshi (Udayapur)	Triyuga Municipality - 7	Camp Rd Gaighat	26.827211	86.621675	1108, 1243, 159, 1100, 1101, 1102, 1103, 1104, 165, 1107, 156	Bhumrasu wa-9ka
15	EVCS/131011/NH0 2 - 4	Koshi (Ilam)	Suryodaya Municipality - 11	Maghe Aaitabare Suryodaya	26.881577	88.027217	314, 313, 37	Aaitbare
16	EVCS/1140303/NH 09 - 12	Koshi (Udayapur)	Katari Municipality - 3	Katari Bus Park	26.959819	86.36876	-	-
17	EVCS/170306/NH0 8 - 08	Koshi (Dhankuta)	Dhankuta Municipality - 6	Dhankuta	26.981398	87.316212	765, 1747, 1055, 2082, 1055, 1053, 1054, 1747, 2082	Nigale6
18	EVCS/170603/NH0 3 - 21	Koshi (Dhankuta)	Pakhribas Municipality - 3	Pakhribas	27.047492	87.298883	950, 937, 900, 828	Phangduwa 7
19	EVCS/120602/NH0 3 - 23	Koshi (Panchthar)	Phidim Municipality - 2	Phidim Bus Park	27.145527	87.756878	2209, 414, 591, 487, 394, 413, 334, 585,	Phidim2
20	EVCS/1140314/NH 03 - 18	Koshi (Udayapur)	Katari Municipality - 14	Ghurmi	27.174023	86.395861	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
21	EVCS/1130901/NH 03 - 19	Koshi (Khotang)	Rupakot Majhuwagadhi Municipality - 1	Diktel Bus Park	27.217536	86.800737	2455, 2463, 2453, 1126, 2465, 1507, 2333, 2331	Diktel_kho tang
22	EVCS/190208/NH1 0 - 1	Koshi (Sankhuwasabha)	Chainpur Municipality - 8	Chainpur	27.280881	87.290259	693, 697, 695	Baneshwar 1
23	EVCS/110607/NH0 2 - 6	Koshi (Taplejung)	Phungling Municipality - 7	Phungling	27.352278	87.662653	764, 463, 464, 911, 36, 748, 764, 1023	Dokhu_Ta plejung
24	EVCS/190501/NH0 8 - 10	Koshi (Sankhuwasabha)	Khandbari Municipality - 1	Khandbari Bus Park	27.374792	87.209626	1225, 6, 398, 1140, 1227	3
25	EVCS/1110709/NH 75 - 1	Koshi (Solukhumbu)	Solududhakunda Municipality - 9	Gorakhani	27.462844	86.504786	108, 354, 344, 346	Gorakhani5 ,6
26	EVCS/2151701/NH 14 - 1	Madhesh (Saptari)	Tilathi Koiladi Gaunpalika - 1	Tilathi	26.457504	86.774094	-	-
27	EVCS/2151202/NH 14 - 2	Madhesh (Saptari)	Rajbiraj Municipality - 2	Rajbiraj Bus Park	26.54034	86.757357	-	-
28	EVCS/2151208/NH 05 - 31	Madhesh (Saptari)	Rajbiraj Municipality - 8	Rajbiraj	26.549597	86.748353	-	-
29	EVCS/2160402/NH 16 - 2	Madhesh (Siraha)	Bhagawanpur Gaunpalika - 2	Nahara Rigoul	26.600984	86.485996	-	-
30	EVCS/2161617/NH 20 - 1	Madhesh (Siraha)	Siraha Municipality - 17	Madar Bus Station	26.618666	86.18474	-	-
31	EVCS/2150106/NH 01 - 17	Madhesh (Saptari)	Agnisair Krishna Savaran Gaunpalika - 6	Bakdhauwa	26.645827	86.824808	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
32	EVCS/2150908/NH 14 - 3	Madhesh (Saptari)	Kanchanrup Municipality - 8	Kanchanrup	26.646387	86.917875		
33	EVCS/2171605/NH 22 - 1	Madhesh (Dhanusha)	Nagarain Municipality - 5	Nagaraine	26.646663	85.926522	54, 864, 522, 614, 762, 678, 57, 384, 677, 761, 676, 613, 462, 463, 464, 674, 49, 254	Nagarain2k ha
34	EVCS/2180708/NH 28 - 1	Madhesh (Mahottari)	Jaleswor Municipality - 8	Kanya School Jaleshor	26.654592	85.794025	-	-
35	EVCS/2161001/NH 01 - 19	Madhesh (Siraha)	Lahan Municipality - 1	Lahan Bus Station	26.715609	86.471447	-	-
36	EVCS/2171004/NH 05 - 26	Madhesh (Dhanusha)	Janakpur Sub- Metropolitan - 4	Namaskar chowk Janakpur	26.724015	85.921747	3,1	169139512
37	EVCS/2160611/NH 01 - 20	Madhesh (Siraha)	Dhangadhimai Municipality - 11	Dhangadi	26.737321	86.421313	-	-
38	EVCS/2171014/NH 22 - 3	Madhesh (Dhanusha)	Janakpur Sub- Metropolitan - 14	Mujeliya	26.760252	85.928782	83, 235, 116, 117, 124, 3	169127510
39	EVCS/2320808/NH 36 - 1	Madhesh (Rautahat)	Gaur Municipality - 8	new Gaur Bus Park	26.774605	85.270981	-	-
40	EVCS/2191802/NH 05 - 21	Madhesh (Sarlahi)	Malangawa Municipality - 2	Malangwa Bus Park	26.849096	85.55262	2002	555701000
41	EVCS/2191804/NH 32 - 1	Madhesh (Sarlahi)	Malangawa Municipality - 4	Shiva Sagar Chowk Malangawa	26.863018	85.557013	44, 5, 7, 11, 46	Malangawa 4

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
42	EVCS/2160902/NH 01 - 23	Madhesh (Siraha)	Karjanha Municipality - 2	Badharamal	26.884466	86.157795	-	-
43	EVCS/2180301/NH 01 - 26	Madhesh (Mahottari)	Bardibas Municipality - 1	Bardibas	26.992165	85.888792	-	-
44	EVCS/2340316/UR - 01	Madhesh (Parsa)	Birgunj Metropolitan - 16	Birgunj Bus Park	27.010363	84.887119	4, 0, 9986	birganj- 19data
45	EVCS/2330602/NH 35 - 2	Madhesh (Bara)	Kalaiya Sub- Metropolitan - 2	Kalaiya	27.042027	85.00406	-	-
46	EVCS/2191706/NH 01 - 28	Madhesh (Sarlahi)	Lalbandi Municipality - 6	Lalbandi	27.050488	85.640576	764, 836, 217, 225, 217, 218, 24	Paththarkot 9cha
47	EVCS/2191308/NH 01 - 29	Madhesh (Sarlahi)	Hariwan Municipality - 8	Hariyon	27.086334	85.567354	0,43	Hariaun7ka
48	EVCS/2330523/NH 41 - 1	Madhesh (Bara)	Jitpur Simara Sub-Metropolitan - 23	Rampur Tokani	27.088706	84.930768	-	-
49	EVCS/2320302/NH 01 - 30	Madhesh (Rautahat)	Chandrapur Municipality - 2	Chandrapur	27.111987	85.373085	-	-
50	EVCS/2330502/NH 41 - 3	Madhesh (Bara)	Jitpur Simara Sub-Metropolitan - 2	Gadhimai	27.166359	84.975638	-	-
51	EVCS/2330501/NH 01 - 32	Madhesh (Bara)	Jitpur Simara Sub-Metropolitan - 1	Pathlaiya	27.200312	84.981165	-	-
52	EVCS/2341402/NH 42 - 1	Madhesh (Parsa)	Thori Gaunpalika - 2	Thori	27.364558	84.604279	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
53	EVCS/3200101/NH 09 - 13	Bagmati (Sindhuli)	Dudhouli Municipality - 1	Hatpate	27.038703	86.124938	-	-
54	EVCS/3200509/NH 13 - 1	Bagmati (Sindhuli)	Kamalamai Municipality - 9	Bhiman Bus Park	27.100043	85.961633	-	-
55	EVCS/3200507/NH 13 - 2	Bagmati (Sindhuli)	Kamalamai Municipality - 7	Kamalamai	27.196092	85.921929	-	-
56	EVCS/3200506/NH 09 - 14	Bagmati (Sindhuli)	Kamalamai Municipality - 6	Sindhuli Bus Park	27.210576	85.911346	-	-
57	EVCS/3200704/NH 03 - 17	Bagmati (Sindhuli)	Phikkal Gaunpalika - 4	Sokhutar	27.243658	86.28788	-	-
58	EVCS/3200806/NH 13 - 5	Bagmati (Sindhuli)	Sunkoshi Gaunpalika - 6	Sitalpati	27.382686	85.963684	-	-
59	EVCS/3310406/NH 37 - 1	Bagmati (Makawanpur)	Hetauda Sub- Metropolitan - 6	Hatiya Marga Hetauda	27.402807	85.080326	8392, 8393, 6566, 8387, 6565, 12103, 8388, 6567	Hetauda6
60	EVCS/3310410/NH 01 - 35	Bagmati (Makawanpur)	Hetauda Sub- Metropolitan - 10	Hetauda Bus Park	27.430353	85.028548	2852, 27, 28	Hetauda10
61	EVCS/3350122/NH 77 - 1	Bagmati (Chitawan)	Bharatpur Metropolitan - 22	Pathihani Chitwan	27.565179	84.345	1157180	Patihani1
62	EVCS/3240902/NH 13 - 7	Bagmati (Kabhrepalancho k)	Namobuddha Municipality - 2	Bhakunde Besi	27.57234	85.638397	2232, 2785, 3899, 671, 2231, 2694, 2692, 2959, 3015, 2695, 4119	Phulbari_k abhre

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
63	EVCS/3250210/NH 37 - 2	Bagmati (Lalitpur)	Godawari Municipality - 10	Chapagaun	27.586829	85.319591	311	Chapagau6 ka
64	EVCS/3241007/NH 15 - 3	Bagmati (Kabhrepalancho k)	Panauti Municipality - 7	Panauti Bus Park	27.586971	85.513268	0, 11	Indreshwar 4_kabhre
65	EVCS/3350602/NH 01 - 37	Bagmati (Chitawan)	Rapti Municipality - 2	Piple	27.59181	84.684286	-	-
66	EVCS/3250209/NH 37 - 3	Bagmati (Lalitpur)	Godawari Municipality - 9	Karyabinayak	27.601314	85.313172	203, 120, 112	Champi5ga
67	EVCS/3250509/NH 15 - 2	Bagmati (Lalitpur)	Mahalaxmi Municipality - 9	Lamatar	27.632135	85.392545	196, 195, 205	Lamatar2K ha2
68	EVCS/3250421/NH 38 - 2	Bagmati (Lalitpur)	Lalitpur Metropolitan - 21	Khokana Bus Park	27.635929	85.300521	10, 17, 16, 218, 9990	Khokana1k ha
69	EVCS/3250428/UR - 06	Bagmati (Lalitpur)	Lalitpur Metropolitan - 28	Harisiddhi	27.642761	85.340739	119, 9985, 120, 694, 124, 311	Harisiddi2k ha1
70	EVCS/3241106/NH 34 - 09	Bagmati (Kabhrepalancho k)	Panchkhal Municipality - 6	Panchkhal	27.645954	85.620116	395	Panchakha 6Kabhre
71	EVCS/3250425/NH 37 - 4	Bagmati (Lalitpur)	Lalitpur Metropolitan - 25	Bhaisepati	27.646811	85.305268	112, 115, 114, 113, 108, 109	Saibu2ka
72	EVCS/3260410/NH 34 - 05	Bagmati (Bhaktapur)	Suryabinayak Municipality - 10	Nalinchowk	27.649529	85.463142	359, 11, 577, 578, 355 8	Chittapol6

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
73	EVCS/3250417/NH 39 - 12	Bagmati (Lalitpur)	Lalitpur Metropolitan - 17	B&B Gwarko	27.66446	85.329783	632, 1001, 1052, 633, 945, 944, 891, 943, 732	Lalitpur6K ha
74	EVCS/3250405/UR - 24	Bagmati (Lalitpur)	Lalitpur Metropolitan - 5	Patan Hospital parking	27.66841	85.321178	82, 75	Lalitpur5ng a
75	EVCS/3260101/NH 34 - 04	Bagmati (Bhaktapur)	Bhaktapur Municipality - 1	Sallaghari Ground	27.672532	85.407226	15, 512, 49, 513, 514, 482, 14, 51, 50, 21	Katunje9
76	EVCS/3270710/UR - 04	Bagmati (Kathmandu)	Kirtipur Municipality - 10	Kirtipur	27.675708	85.288889	2, 356	Kirtipur3
77	EVCS/3250403/UR - 23	Bagmati (Lalitpur)	Lalitpur Metropolitan - 3	Labim Mall Pulchowk	27.677019	85.316806	121, 278, 118, 117, 116	Lalitpur3ja
78	EVCS/3250403/UR - 22	Bagmati (Lalitpur)	Lalitpur Metropolitan - 3	Krishna Galli Marg	27.679664	85.319301	373, 375, 162, 360, 361, 424, 357, 178, 365	Lalitpur3ja
79	EVCS/3250410/UR - 22	Bagmati (Lalitpur)	Lalitpur Metropolitan - 10	IOE parking	27.682194	85.320111	143, 149, 144, 9995	Lalitpur1ch a
80	EVCS/3350110/NH 01 - 40	Bagmati (Chitawan)	Bharatpur Metropolitan - 10	Chaubiskothi Bhartpur	27.683708	84.430399	40	Bharatpur5
81	EVCS/3270614/NH 39 - 11	Bagmati (Kathmandu)	Kathmandu Metropolitan - 14	Balkhu	27.685789	85.292343	9903	Kalanki14
82	EVCS/3270631/UR - 25	Bagmati (Kathmandu)	Kathmandu Metropolitan - 31	Civil Hospital Baneshwor	27.687148	85.338989	57, 55	Kathamand u10

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
83	EVCS/3270207/NH 41 - 8	Bagmati (Kathmandu)	Chandragiri Municipality - 7	Chandragiri	27.690336	85.225053	112, 111, 29, 113, 9979, 96	Tha Mahadevst han7
84	EVCS/3270614/NH 39 - 10	Bagmati (Kathmandu)	Kathmandu Metropolitan - 14	Bhat-Bhateni Khasi bazar	27.691075	85.28485	95, 68, 101, 97, 82, 83, 94, 96, 103, 92, 99, 67, 93, 430, 428, 429, 100, 125, 59	Kalanki14
85	EVCS/3270629/UR - 21	Bagmati (Kathmandu)	Kathmandu Metropolitan - 29	Bhatbhateni Supermarket Anamnagar	27.692686	85.328629	166, 170, 168, 112, 172, 1	KaMAPA3 2
86	EVCS/3270609/NH 39 - 01	Bagmati (Kathmandu)	Kathmandu Metropolitan - 9	Airport	27.698723	85.353895	308, 133, 9, 33, 4, 3	Kathamand u9
87	EVCS/3270622/UR - 20	Bagmati (Kathmandu)	Kathmandu Metropolitan - 22	Civil Mall Sundhara	27.69919	85.313054	2313, 1388, 2299, 2604, 1376, 2609, 2603, 2602, 2608, 2601, 1721, 2607, 2600, 2314, 1392, 1391, 1389, 1414	Kathamand u11
88	EVCS/3270613/UR - 03	Bagmati (Kathmandu)	Kathmandu Metropolitan - 13	Soaltee Hotel Tahachal Marg	27.700426	85.290588	49, 106, 41, 106	Kalanki13
89	EVCS/3270622/UR - 19	Bagmati (Kathmandu)	Kathmandu Metropolitan - 22	Sundhara	27.70077	85.312317	149, 148, 2242, 104	Kathamand u22
90	EVCS/3350101/NH 77 - 5	Bagmati (Chitawan)	Bharatpur Metropolitan - 1	Kailash Tole Bharatpur	27.704507	84.450318	1064, 633	Bharatpur1
91	EVCS/3270627/UR - 18	Bagmati (Kathmandu)	Kathmandu Metropolitan - 27	Ratnapark	27.70589	85.313872	2069, 381, 2068, 381	Kathamand u30

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
92	EVCS/3270608/NH 39 - 04	Bagmati (Kathmandu)	Kathmandu Metropolitan - 8	Pingalastan	27.706498	85.345789	112, 147, 71, 149, 73, 171, 173, 164, 165, 166, 192, 191, 178, 148, 176, 74, 72, 146, 93, 76, 94, 121, 111, 169, 59	Kathamand u9
93	EVCS/3270601/UR - 17	Bagmati (Kathmandu)	Kathmandu Metropolitan - 1	Yak & Yeti - Hotel Durbar Marg	27.710856	85.3197	2986, 546, 1187, 2989	Kathamand u1
94	EVCS/3270615/UR - 02	Bagmati (Kathmandu)	Kathmandu Metropolitan - 15	Chhauni Hospital	27.712161	85.291567	30	Kalanki15
95	EVCS/3270601/UR - 16	Bagmati (Kathmandu)	Kathmandu Metropolitan - 1	Marriott Hotel Manakamana Marg	27.712646	85.324446	2371, 1794, 1797, 1418, 1417, 2373	Kathamand u1
96	EVCS/3270601/UR - 15	Bagmati (Kathmandu)	Kathmandu Metropolitan - 1	Narayanhiti Path	27.71337	85.31734	406, 637	Kathamand u1
97	EVCS/3300207/NH 41 - 7	Bagmati (Dhading)	Dhunibesi Municipality - 7	Shim Bazar Naubise	27.718641	85.152926	654, 141, 488, 487, 522, 305	naubise7ga _dhading
98	EVCS/3270605/UR - 13	Bagmati (Kathmandu)	Kathmandu Metropolitan - 5	Bhatbhateni Naxal	27.718819	85.331721	133, 86, 132, 2, 44, 1, 3	Kathamand u5
99	EVCS/3270607/UR - 10	Bagmati (Kathmandu)	Kathmandu Metropolitan - 7	Boudhanath	27.71904	85.353029	505, 551, 244, 245, 474, 502, 503	Kathamand u7
100	EVCS/3270602/UR - 14	Bagmati (Kathmandu)	Kathmandu Metropolitan - 2	Kumari Mai Marg	27.720278	85.321064	151, 152, 705, 309	Kathamand u2

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
101	EVCS/3270606/UR - 11	Bagmati (Kathmandu)	Kathmandu Metropolitan - 6	Taragaon	27.721341	85.355738	14, 29	Kathamand u6
102	EVCS/3270907/UR - 09	Bagmati (Kathmandu)	Shankharapur Municipality - 7	Shankharapur	27.731288	85.465012	73, 145, 144, 76, 215, 74, 75	Salkha1Ka
103	EVCS/3270626/NH 39 - 08	Bagmati (Kathmandu)	Kathmandu Metropolitan - 26	Gongabu Bus Park	27.731533	85.308511	5, 7	Kathamand u29
104	EVCS/3270603/NH 39 - 07	Bagmati (Kathmandu)	Kathmandu Metropolitan - 3	Maharajgunj	27.737412	85.33176	167	Kathamand u3
105	EVCS/3270404/UR - 08	Bagmati (Kathmandu)	Gokarneshwor Municipality - 4	Gokarneshwor	27.740081	85.389183	261, 248, 250, 251	Gokarna2
106	EVCS/3230105/NH 34 - 11	Bagmati (Sindhupalchok)	Balefi Gaunpalika - 5	Phulping Dandagaun	27.74519	85.803147	588, 228, 591, 329, 589, 818, 328	Phulpingda dagau7
107	EVCS/3270603/UR - 12	Bagmati (Kathmandu)	Kathmandu Metropolitan - 3	Bansbari	27.745579	85.342844	-	-
108	EVCS/3271106/NH 40 - 1	Bagmati (Kathmandu)	Tokha Municipality - 6	Grande International Hospital Tokha	27.752682	85.325863	16, 809, 810, 808, 792, 785, 137	Dhapasi4
109	EVCS/3350129/NH 44 - 2	Bagmati (Chitawan)	Bharatpur Metropolitan - 29	Jugedi	27.764248	84.471422	-	-
110	EVCS/3271103/NH 40 - 2	Bagmati (Kathmandu)	Tokha Municipality - 3	Tokha	27.765738	85.329187	23, 138, 37, 137	Saraswati9

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
111	EVCS/3271003/NH 18 - 01	Bagmati (Kathmandu)	Tarakeshwor Municipality - 3	Tarkeshwor Mandir Marg	27.7668	85.269575	190, 94, 334, 335, 196, 319	Jitpur7gaK TM
112	EVCS/3300406/NH 17 - 01	Bagmati (Dhading)	Galchi Gaunpalika - 6	Baireni Galchi	27.796357	84.99704	741, 259, 742, 724, 567	Baireni
113	EVCS/3300107/NH 17 - 04	Bagmati (Dhading)	Benighat Rorang Gaunpalika - 7	Charaundi	27.801481	84.741313	290, 1030, 291, 666, 1338	Benighat2
114	EVCS/3280205/NH 42 - 2	Bagmati (Nuwakot)	Bidur Municipality - 5	Bidur	27.866767	85.117405	3139, 867, 3125, 864, 3048, 3124, 3138, 1606, 1596, 3049, 3098, 3099, 2923, 1598, 1608, 2924, 829, 1447	Bidur9
115	EVCS/3350204/NH 17 - 05	Bagmati (Chitawan)	Ichchhyakamana Gaunpalika - 4	Darechok	27.872975	84.620502	2177, 2410, 2409, 2175, 107	Darechok3
116	EVCS/3280605/NH 03 - 15	Bagmati (Nuwakot)	Likhu Gaunpalika - 5	Thansing, Likhu	27.890005	85.239938	317, 309, 674	Thansing8
117	EVCS/3290105/NH 42 - 4	Bagmati (Rasuwa)	Gosaikunda Gaunpalika - 5	Syapru Besi	28.164119	85.338839	1219, 1221	Syaphru9
118	EVCS/4760811/NH 01 - 42	Gandaki (Nawalparasi_E)	Madhyabindu Municipality - 11	Naya Belhani	27.614206	83.959309	0	Naya belhani
119	EVCS/4390601/NH 47 - 4	Gandaki (Syangja)	Galyang Municipality - 1	Malunga	27.91996	83.649317	811, 921, 922, 810, 924, 923, 925	MaluingaT unibot3
120	EVCS/4380504/NH 17 - 08	Gandaki (Tanahu)	Byas Municipality - 4	Byas	27.982928	84.27243	123, 401, 402	Pharakchau r9

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
121	EVCS/4360708/NH 44 - 3	Gandaki (Gorkha)	Gorkha Municipality - 8	Gorkha	27.985388	84.633266	591	Raniswara3
122	EVCS/4391101/NH 47 - 6	Gandaki (Syangja)	Waling Municipality - 1	Waling	27.986483	83.769271	506, 3940, 505, 3937	Waling3
123	EVCS/4391014/NH 47 - 7	Gandaki (Syangja)	Putalibazar Municipality - 14	Syangja Buspark	28.096039	83.869489	1095, 4315, 4316, 4320, 4317, 4319, 4318, 2506, 1196, 945	Putalibazar 9
124	EVCS/4400429/NH 17 - 11	Gandaki (Kaski)	Pokhara Lekhnath Metropolitan - 29	Lekhnath	28.157731	84.059481	3637, 3638, 2203, 2259	Shisuwa1
125	EVCS/4400417/NH 47 - 9	Gandaki (Kaski)	Pokhara Lekhnath Metropolitan - 17	Chhorepatan Pokhara	28.190449	83.955645	122, 81, 82, 38, 128, 120, 192, 191	Pokhara17
126	EVCS/4400414/NH 17 - 12	Gandaki (Kaski)	Pokhara Lekhnath Metropolitan - 14	Chauthe Pokhara	28.196154	84.017664	34, 81, 37, 39, 38, 36	Pokhara14
127	EVCS/4400425/NH 03 - 13	Gandaki (Kaski)	Pokhara Lekhnath Metropolitan - 25	Hemja, Yamdi Pokhara	28.260142	83.959161	845, 849, 848, 844	Hemja1
128	EVCS/4450202/NH 03 - 11	Gandaki (Baglung)	Baglung Municipality - 2	Baglung Bus Park	28.262627	83.597689	311, 104, 395, 396	Kalika3
129	EVCS/4430208/NH 48 - 1	Gandaki (Myagdi)	Beni Municipality - 8	Beni Bus Park	28.349726	83.567919	1693, 124, 429, 1694, 3, 76,	Arthunge

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
130	EVCS/4420101/NH 48 - 4	Gandaki (Mustang)	Barhagaun Muktikhsetra Gaunpalika - 1	Ranipauwa Muktinath	28.813053	83.858801	0	Kagbeni_N aksaNabha yako
131	EVCS/5501007/NH 50 - 1	Lumbini (Kapilbastu)	Yashodhara Gaunpalika - 7	Maryadpur Kapilbastu	27.461347	82.996836	2055	Bhedauli
132	EVCS/5490606/NH 05 - 10	Lumbini (Rupandehi)	Lumbini Sanskritik Municipality - 6	Lumbini Sanskritik	27.491535	83.288562	1267, 1853, 1265, 1854, 1857, 1061, 1859, 1852, 1855, 1858, 1856, 1265, 1062	Tenuhawa8
133	EVCS/5500701/NH 05 - 09	Lumbini (Kapilbastu)	Mayadevi Gaunpalika - 1	Pakadi Kapilbastu	27.516272	83.153142	565, 1695, 1696, 1760	Pakadi2
134	EVCS/5480410/NH 05 - 11	Lumbini (Nawalparasi_W)	Ramgram Municipality - 10	Nawalparasi Ramgram	27.530502	83.639539	476, 1483, 1485, 1392, 1716, 1536, 469, 1264, 1776, 1484, 1486, 1393, 1607, 1608, 1786, 470, 1786, 470, 1734, 1263, 612	Sukaraul
135	EVCS/5490303/NH 52 - 2	Lumbini (Rupandehi)	Gaidahawa Gaunpalika - 3	Bisunpura	27.563046	83.251663	776, 775, 777, 268, 752, 243, 598, 244, 568, 267, 751	Bargadawa 2kha
136	EVCS/5480601/NH 01 - 43	Lumbini (Nawalparasi_W)	Sunwal Municipality - 1	Sunwal	27.606333	83.648955	0, 1591, 1592, 1593, 1204, 1961, 1960, 1959	Sunawal
137	EVCS/5500805/NH 01 - 48	Lumbini (Kapilbastu)	Shivaraj Municipality - 5	Shivaraj	27.648663	82.871323	0	Birpur8ka

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
138	EVCS/5500104/NH 01 - 46	Lumbini (Kapilbastu)	Banganga Municipality - 4	Banaganga	27.687285	83.172248	1841, 1600, 1259, 1255, 999, 998, 1882, 1005, 1257, 1258, 1416, 1601, 1417, 1010, 1411, 1260, 1881, 1409, 1410, 1408	Gajehada7 ka
139	EVCS/5500301/NH 51 - 1	Lumbini (Kapilbastu)	Buddhabhumi Municipality - 1	Buddhabatika	27.748552	83.044443	0	Mahendrak ot5ga
140	EVCS/5510604/NH 51 - 2	Lumbini (Arghakhanchi)	Sitganga Municipality - 4	Bhedamare Supadeurali	27.837655	83.072096	-	-
141	EVCS/5560801/NH 53 - 1	Lumbini (Dang)	Rapti Gaunpalika - 1	Lalmatiya	27.841615	82.765879	-	-
142	EVCS/5560601/NH 01 - 49	Lumbini (Dang)	Lamahi Municipality - 1	Lamahi Sundabari	27.86008	82.590001	1214	Sonpur8kh a
143	EVCS/5470904/NH 47 - 3	Lumbini (Palpa)	Tansen Municipality - 4	Tansen	27.864537	83.546763	-	-
144	EVCS/5560605/NH 01 - 50	Lumbini (Dang)	Lamahi Municipality - 5	Lamahi Bus Park	27.874175	82.518002	874	Chailahi2c ha
145	EVCS/5570801/NH 01 - 52	Lumbini (Banke)	Rapti Sonari Gaunpalika - 1	Khaskusma	28.014059	82.085916	705, 430, 278, 279, 309, 429, 283, 307, 431, 310, 550, 312, 158, 432	Khaskusm a2
146	EVCS/5560514/NH 54 - 1	Lumbini (Dang)	Ghorahi Sub- Metropolitan - 14	Ghorahi Bus Park	28.047305	82.483369	1320, 875, 823, 705, 706, 887, 888, 350, 248, 13, 113	Ghorahi

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
147	EVCS/5461009/NH 19 - 1	Lumbini (Gulmi)	Resunga Municipality - 9	Resunga	28.066039	83.241638	2841, 2854, 2840, 2844, 2855, 2233, 2857, 2902, 2906	Tamghas
148	EVCS/5570720/NH 58 - 3	Lumbini (Banke)	Nepalgunj Sub- Metropolitan - 20	Manikapur	28.104872	81.65483	601, 247, 238	Manikapur 8
149	EVCS/5561005/NH 55 - 2	Lumbini (Dang)	Tulsipur Sub- Metropolitan - 5	Tulsipur	28.138622	82.300253	67	Tulsipur5G ha
150	EVCS/5570511/NH 01 - 53	Lumbini (Banke)	Kohalpur Municipality - 11	Kohalpur New Buspark	28.197535	81.692702	1454, 295, 292, 274, 310, 291, 31, 293	Kohalpur3 kha
151	EVCS/5580504/NH 59 - 1	Lumbini (Bardiya)	Gulariya Municipality - 4	Gulariya	28.211991	81.348049	-	-
152	EVCS/5570106/NH 01 - 55	Lumbini (Banke)	Baijanath Gaunpalika - 6	Chandani bazar Titihiriya	28.218468	81.581234	201, 202, 1	Titihiriya6
153	EVCS/5580801/NH 01 - 57	Lumbini (Bardiya)	Thakurbaba Municipality - 1	Neulapur	28.446222	81.326431	-	-
154	EVCS/6550901/NH 55 - 3	Karnali (Salyan)	Sharada Municipality - 1	Shreenagar	28.361138	82.197328	667, 2287, 2286, 999994, 68, 664, 666	Khalanga-1
155	EVCS/6590306/NH 58 - 5	Karnali (Surkhet)	Birendranagar Municipality - 6	Birendranagar Bus Park	28.591019	81.618706	77, 0	Katkuwa2
156	EVCS/6600901/NH 03 - 08	Karnali (Dailekh)	Narayan Municipality - 1	Dekendra chowk	28.839896	81.710218	1196, 1077, 1197, 1068, 380, 379, 1067, 579	Narayan-1
157	EVCS/6600101/NH 03 - 07	Karnali (Dailekh)	Aathabis Municipality - 1	sattala	28.961486	81.476371	11	Sattala-6

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
158	EVCS/7711309/NH 62 - 1	Sudur Pashchim (Kailali)	Tikapur Municipality - 9	Thapapur	28.45432	81.051587	540, 103	Dhansingp ur5
159	EVCS/7710101/NH 01 - 59	Sudur Pashchim (Kailali)	Bardagoriya Gaunpalika - 1	Bauniya Bazar	28.660741	81.043591	180	Dododhara 7
160	EVCS/7710403/NH 66 - 1	Sudur Pashchim (Kailali)	Dhangadhi Sub- Metropolitan - 3	Chauraha	28.709434	80.568342	345, 202, 346, 290, 347, 291, 201, 41	Dhangadhi 3
161	EVCS/7710508/NH 01 - 61	Sudur Pashchim (Kailali)	Gauriganga Municipality - 8	Masuriya	28.726722	80.83777	50, 5, 1346, 1345, 4, 2	Masuriya5
162	EVCS/7710704/NH 01 - 63	Sudur Pashchim (Kailali)	Godawari Municipality - 4	Attariya	28.813224	80.556254	1	Malakheti7
163	EVCS/7720410/NH 01 - 69	Sudur Pashchim (Kanchanpur)	Bhimdatta Municipality - 10	Gadda ckauki	28.990775	80.129116	1920, 1919, 1916, 1921	Mahendran agar10
164	EVCS/7730712/NH 09 - 27	Sudur Pashchim (Dadeldhura)	Parashuram Municipality - 12	Parashuram	29.130052	80.352529	795, 794, 593, 772, 797, 771, 787, 796	Jogbudha1t a
165	EVCS/7700404/NH 03 - 05	Sudur Pashchim (Doti)	Dipayal Silgadi Municipality - 4	Doti Bus Park Dipayal	29.249704	80.944142	1675, 1673, 796, 1674	Dipayal- silgadhi 7
166	EVCS/7700910/NH 03 - 04	Sudur Pashchim (Doti)	Shikhar Municipality - 10	Banedugri Sain	29.292014	80.782857	278, 221, 342, 341, 279, 277	Banlek2
167	EVCS/7730305/NH 03 - 03	Sudur Pashchim (Dadeldhura)	Amargadhi Municipality - 5	Buspark,Dadeld hura	29.297181	80.590741	8, 4	Kamerotar 11
168	EVCS/7740102/NH 03 - 02	Sudur Pashchim (Baitadi)	Dasharathchanda Municipality - 2	Khalanga	29.524506	80.466962	943, 945	Dehimanda un-8
<b>Phase-II</b>								
1	EVCS/151304/NH0 5 - 34	Koshi (Morang)	Rangeli Municipality - 4	Drabesha	26.464819	87.465653	163, 74, 333	Rangeli8

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
2	EVCS/140803/NH0 5 - 36	Koshi (Jhapa)	Gauriganj Gaunpalika - 3	Gauriganj Chowk	26.468683	87.712503	2, 244	gauriganj7
3	EVCS/160801/NH0 5 - 32	Koshi (Sunsari)	Harinagar Gaunpalika - 1	Ramnagar Bhutaha	26.535048	87.114404	913, 716, 462, 460, 459, 458, 457, 496, 698, 699, 717, 803	Ramnagar8
4	EVCS/161104/NH0 1 - 15	Koshi (Sunsari)	Koshi Gaunpalika - 4	Sripurjabdi	26.585336	87.01012	463, 457, 421, 465, 467, 463, 453, 461, 455, 159	Sripurjabdi 9
5	EVCS/160904/NH0 1 - 14	Koshi (Sunsari)	Inaruwa Municipality - 4	Inaruwa Bus Park	26.60062	87.137935	-	-
6	EVCS/140403/NH0 4 - 2	Koshi (Jhapa)	Birtamod Municipality - 3	Birtamod	26.620017	87.991553	1166	Anarmani7
7	EVCS/140105/NH0 1 - 05	Koshi (Jhapa)	Arjundhara Municipality - 5	Laxmipura	26.641198	87.951328	1798, 20002, 616, 1799	PakhaKhop i6
8	EVCS/140405/NH0 1 - 04	Koshi (Jhapa)	Birtamod Municipality - 5	Birtamod	26.64537	88.000671	344	Anarmani3
9	EVCS/141303/NH0 1 - 06	Koshi (Jhapa)	Kankai Municipality - 3	Kankai	26.647899	87.887955	404	Shivagunj7
10	EVCS/141203/NH0 1 - 08	Koshi (Jhapa)	Kamal Gaunpalika - 3	Kamal Gaun Palika	26.651309	87.755974	-	-
11	EVCS/141413/NH0 1 - 03	Koshi (Jhapa)	Mechinagar Municipality - 13	Duwagadhi	26.653215	88.057578	3458, 133, 1996, 1997, 3460, 3459	Duwagadhi 4
12	EVCS/141410/NH0 1 - 02	Koshi (Jhapa)	Mechinagar Municipality - 10	Mechinagar	26.65619	88.088311	1045, 224, 225, 48, 227, 230, 16	mechi2
13	EVCS/140607/NH0 1 - 09	Koshi (Jhapa)	Damak Municipality - 7	Damak	26.658153	87.702145	0, 71	DamakAay og12

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
14	EVCS/151704/NH0 1 - 10	Koshi (Morang)	Uralabari Municipality - 4	Uralabari	26.664821	87.625135	5003, 3836, 3837, 5002, 2525	Madhumalla5
15	EVCS/150102/NH0 1 - 11	Koshi (Morang)	Belbari Municipality - 2	Belbari	26.665433	87.401371	1360, 1363, 1361, 1362, 67	Haraicha5
16	EVCS/161005/NH0 1 - 12	Koshi (Sunsari)	Itahari Sub- Metropolitan - 5	Itahari	26.667454	87.258087	315, 319, 318, 317, 316, 236, 307, 314, 313, 312, 450 ,0	Itahari5
17	EVCS/151004/NH0 9 - 04	Koshi (Morang)	Letang Municipality - 4	letang Bus Park	26.735969	87.507269	-	-
18	EVCS/151107/NH0 9 - 03	Koshi (Morang)	Miklajung Gaunpalika - 7	Madhumalla	26.739232	87.665775	-	-
19	EVCS/1140705/NH 16 - 4	Koshi (Udayapur)	Triyuga Municipality - 5	Gaighat	26.795738	86.641821	60, 67, 64, 68, 61, 98, 31	Dauri3Kha
20	EVCS/160508/NH0 9 - 06	Koshi (Sunsari)	Dharan Sub- Metropolitan - 8	Radio Nepal Marg	26.799672	87.278687	470, 186, 476, 735, 760, 733, 475, 509	Basaha5ka
21	EVCS/1140203/NH 09 - 08	Koshi (Udayapur)	Chaudandigadhi Municipality - 3	Beltar Basaha	26.802566	86.951608	-	-
22	EVCS/160513/NH0 8 - 06	Koshi (Sunsari)	Dharan Sub- Metropolitan - 13	Shiv Dhara Chowk	26.836334	87.294445	1524, 1946, 533, 193, 358, 357, 512, 534, 403, 1527, 1525, 1528, 30003	Bajhagara9
23	EVCS/131006/NH0 2 - 3	Koshi (Ilam)	Suryodaya Municipality - 6	Kanyam	26.851165	88.084809	2, 76, 77	Kanyam5
24	EVCS/160101/NH0 6 - 1	Koshi (Sunsari)	Barah Municipality - 1	Barahakshetra	26.874074	87.164983	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
25	EVCS/170706/NH0 8 - 07	Koshi (Dhankuta)	Sangurigadhi Gaunpalika - 6	Namaste Waterfall Bhedetar	26.877445	87.33192	689, 716, 688, 389	Karkichhap 3
26	EVCS/1140301/NH 20 - 4	Koshi (Udayapur)	Katari Municipality - 1	Belsot Katari	26.905157	86.257923	-	-
27	EVCS/1140806/NH 09 - 11	Koshi (Udayapur)	Udayapurgadhi Gaunpalika - 6	Nepaltar	26.909085	86.517544	399, 427, 62, 394, 426, 270	Pachabati4 ka
28	EVCS/120203/NH0 2 - 5	Koshi (Panchthar)	Falgunanda Gaunpalika - 3	Chamaita	27.032054	87.807192	257, 569, 570, 641, 691, 692, 697, 698, 173	Pauwasarta p7
29	EVCS/130902/NH7 4 - 2	Koshi (Ilam)	Sandakpur Gaunpalika - 2	Ilam	27.063837	87.946638	76, 77, 78, 79, 215	Maimajhu wa7
30	EVCS/180301/NH1 0 - 2	Koshi (Terhathum)	Laligurans Municipality - 1	Khandbari Tute	27.154348	87.407943	12, 13	Basantapur Sawara9
31	EVCS/1120702/NH 75 - 2	Koshi (Okhaldhunga)	Siddhicharan Municipality - 2	Thulachhap	27.257304	86.581517	197, 255	Thulachhap 1
32	EVCS/1120711/NH 20 - 5	Koshi (Okhaldhunga)	Siddhicharan Municipality - 11	Siddhicharan	27.303464	86.507587	49, 751, 659, 682, 681, 566	Okhaldhun ga4
33	EVCS/190509/NH0 8 - 09	Koshi (Sankhuwasabha)	Khandbari Municipality - 9	Tumlingtar	27.321121	87.197309	1417, 1780, 1414, 1416, 1418, 1549, 1548, 1550	8
34	EVCS/2160404/NH 16 - 1	Madhesh (Siraha)	Bhagawanpur Gaunpalika - 4	Inarwa	26.557257	86.475631	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
35	EVCS/2150910/NH 01 - 16	Madhesh (Saptari)	Kanchanrup Municipality - 10	Kanchanrup	26.614074	86.901847	-	-
36	EVCS/2151507/NH 01 - 18	Madhesh (Saptari)	Shambhunath Municipality - 7	Shambhunath	26.633422	86.682648	-	-
37	EVCS/2161601/NH 05 - 28	Madhesh (Siraha)	Siraha Municipality - 1	Mahabir chowk	26.652333	86.207542	-	-
38	EVCS/2171023/NH 22 - 2	Madhesh (Dhanusha)	Janakpur Sub- Metropolitan - 23	Bindhi, Janakpur	26.712002	85.9013	1651, 811, 206, 1650, 808, 812, 1515, 1516, 1570, 1571, 2176, 807	Winhi4ka
39	EVCS/2180808/NH 05 - 25	Madhesh (Mahottari)	Loharpatti Municipality - 8	Bhramarpura	26.726833	85.849959	-	-
40	EVCS/2160501/NH 20 - 3	Madhesh (Siraha)	Bishnupur Gaunpalika - 1	Bishnupur Pra.Ma	26.732084	86.256534	-	-
41	EVCS/2151602/NH 16 - 3	Madhesh (Saptari)	Surunga Municipality - 2	Hardiya	26.754198	86.543433	-	-
42	EVCS/2160706/NH 01 - 21	Madhesh (Siraha)	Golbazar Municipality - 6	Golbazar	26.795032	86.32633	74, 60, 99999, 3611, 9999996, 2919, 2920	Asanpur_7 ka
43	EVCS/2181305/NH 28 - 3	Madhesh (Mahottari)	Ramgopalpur Municipality - 5	Ramgopalpur	26.82681	85.800891	-	-
44	EVCS/2161206/NH 01 - 22	Madhesh (Siraha)	Mirchaiya Municipality - 6	Mirchaiya	26.827349	86.260066	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
45	EVCS/2170406/NH 22 - 4	Madhesh (Dhanusha)	Chhireswornath Municipality - 6	Chhireswarnat h	26.859027	85.962354	251, 1075	Hariharpur lga
46	EVCS/2170609/NH 01 - 24	Madhesh (Dhanusha)	Dhanusadham Municipality - 9	Dhanusadham	26.908435	86.035935	899, 932, 243, 241, 429, 897, 923, 922, 99, 981, 983, 984, 985, 931, 896, 239, 921, 925	Yagyabhu mi7nga
47	EVCS/2171306/NH 01 - 25	Madhesh (Dhanusha)	Mithila Municipality - 6	Mithila	26.927796	85.963122	2721, 2722, 1567, 598, 597, 344	Dhalkebar5 ka
48	EVCS/2170705/NH 79 - 1	Madhesh (Dhanusha)	Ganeshman Charnath Municipality - 5	Ganeshman Charnath	26.935295	86.145342	141, 85, 140, 61	Tallo Godar2
49	EVCS/2320704/NH 36 - 3	Madhesh (Rautahat)	Garuda Municipality - 4	Garuda	26.944446	85.313137	-	-
50	EVCS/2180314/NH 28 - 4	Madhesh (Mahottari)	Bardibas Municipality - 14	Bardibas	26.980924	85.886318	-	-
51	EVCS/2340324/NH 05 - 15	Madhesh (Parsa)	Birgunj Metropolitan - 24	Padam Road Birgunj	27.028494	84.871475	-	-
52	EVCS/2330603/NH 05 - 16	Madhesh (Bara)	Kalaiya Sub- Metropolitan - 3	Kalaiya	27.031495	84.99434	-	-
53	EVCS/2191702/NH 32 - 2	Madhesh (Sarlahi)	Lalbandi Municipality - 2	Netraganj	27.062774	85.584176	308, 507, 508, 505, 506, 503, 504	Jabadi9jha
54	EVCS/2330507/NH 41 - 2	Madhesh (Bara)	Jitpur Simara Sub-Metropolitan - 7	Gadhimai	27.139233	84.962974	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
55	EVCS/2331007/NH 01 - 31	Madhesh (Bara)	Nijgadh Municipality - 7	Nijgadh	27.178689	85.191071	-	-
56	EVCS/2330521/NH 01 - 33	Madhesh (Bara)	Jitpur Simara Sub-Metropolitan - 21	Amlekhganj	27.282093	84.992895	-	-
57	EVCS/3200504/NH 13 - 3	Bagmati (Sindhuli)	Kamalamai Municipality - 4	Kamalamai	27.233348	85.913544	-	-
58	EVCS/3200307/NH 13 - 4	Bagmati (Sindhuli)	Golanjor Gaunpalika - 7	Bhimeshwor	27.328819	85.994211	-	-
59	EVCS/3310409/NH 01 - 34	Bagmati (Makawanpur)	Hetauda Sub- Metropolitan - 9	Hetauda	27.396098	85.024991	494, 496, 499, 7065, 7066, 10830	Hetauda9
60	EVCS/3350508/NH 05 - 13	Bagmati (Chitawan)	Madi Municipality - 8	Madi	27.436445	84.380766	161, 27, 26	Ayodhyapu ri6
61	EVCS/3200802/NH 13 - 6	Bagmati (Sindhuli)	Sunkoshi Gaunpalika - 2	Dumja	27.445216	85.824756	-	-
62	EVCS/3310807/NH 01 - 36	Bagmati (Makawanpur)	Manahari Gaunpalika - 7	Manahari	27.540429	84.799209	0	Manahari6
63	EVCS/3350127/NH 77 - 2	Bagmati (Chitawan)	Bharatpur Metropolitan - 27	Narayani	27.578804	84.230271	13, 16	Meghauri5
64	EVCS/3250422/NH 33 - 2	Bagmati (Lalitpur)	Lalitpur Metropolitan - 22	Karyabinayak	27.613462	85.29633	20, 139, 229	Bungamati 6
65	EVCS/3350408/NH 01 - 38	Bagmati (Chitawan)	Khairahani Municipality - 8	Khairahani	27.613625	84.563234	710, 715, 320, 695, 681, 806, 725, 711, 132, 1456	Khairhani8

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
66	EVCS/3240504/NH 34 - 07	Bagmati (Kabhrepalancho k)	Dhulikhel Municipality - 4	Budol	27.627326	85.537573	58, 51, 50, 49, 52, 48, 39	Dhulikhel7 Kabhre
67	EVCS/3350710/NH 01 - 39	Bagmati (Chitawan)	Ratnanagar Municipality - 10	Ratnanagar	27.631643	84.492711	834, 1810, 1811, 1812, 1813, 1814, 1815, 1816, 1830, 710, 1829, 1828, 837, 1311, 836, 838	Panchakan ya6ka
68	EVCS/3240114/NH 34 - 06	Bagmati (Kabhrepalancho k)	Banepa Municipality - 14	Sanga	27.631998	85.49775	2123, 1394, 3501, 3477, 905	sanga
69	EVCS/3270706/NH 38 - 1	Bagmati (Kathmandu)	Kirtipur Municipality - 6	Kirtipur, pandechap	27.654906	85.272414	376, 2, 218, 373, 372, 374, 375, 376, 377, 369, 183, 233, 4, 7, 45, 184, 113, 191, 154	Kirtipur15
70	EVCS/3350112/NH 77 - 6	Bagmati (Chitawan)	Bharatpur Metropolitan - 12	Rino tal Bharatpur	27.666131	84.459328	3893, 4351, 3883, 3894, 2283, 4337	Bharatpur6
71	EVCS/3260303/NH 34 - 02	Bagmati (Bhaktapur)	Madhyapur Thimi Municipality - 3	Madhyapur Thimi	27.673922	85.378941	9, 642, 275, 274, 11, 4, 642, 5, 22, 1, 217	Madhyapur 15
72	EVCS/3270632/NH 39 - 13	Bagmati(Kathma ndu)	Kathmandu Metropolitan - 32	Koteshwor	27.675014	85.344631	206, 54, 84, 189, 72, 86, 87, 89, 203, 205, 56, 55, 1	Kathamand u35
73	EVCS/3350116/NH 77 - 4	Bagmati (Chitawan)	Bharatpur Metropolitan - 16	Gitanagar Chitwan	27.681766	84.331077	524, 1491, 627, 1492, 99999	Mangalpur 9
74	EVCS/3270610/NH 34 - 01	Bagmati (Kathmandu)	Kathmandu Metropolitan - 10	Everest Hotel Baneshwor	27.689036	85.333498	297, 296, 295, 154, 134, 135	Kathamand u10

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
75	EVCS/3270609/NH 39 - 02	Bagmati (Kathmandu)	Kathmandu Metropolitan - 9	TIA Parking Airport	27.700435	85.354885	-	-
76	EVCS/3270509/UR - 07	Bagmati (Kathmandu)	Kageshwori Manahora Municipality - 9	Gothatar	27.700437	85.381224	153, 32, 391, 31, 407, 30	Gothatar
77	EVCS/3230409/NH 34 - 10	Bagmati (Sindhupalchok)	Chautara SangachokGadhi Municipality - 9	Kadambas	27.701749	85.754286	2097, 1609, 2098, 1607, 1602	Sangachoc k1
78	EVCS/3270609/NH 39 - 03	Bagmati (Kathmandu)	Kathmandu Metropolitan - 9	Domestic Parking TIA	27.702738	85.357728	4	Kathamand u9
79	EVCS/3270626/NH 39 - 06	Bagmati (Kathmandu)	Kathmandu Metropolitan - 26	BG mall Gangabu	27.734513	85.310553	-	-
80	EVCS/3300205/NH 21 - 2	Bagmati (Dhading)	Dhunibesi Municipality - 5	Jeewanpur	27.740635	85.19409	-	-
81	EVCS/3230405/NH 31 - 1	Bagmati (Sindhupalchok)	Chautara SangachokGadhi Municipality - 5	Chautara Marg	27.770653	85.722232	844, 842, 841, 840, 389, 381, 590, 384, 345, 344	Chautara
82	EVCS/3271102/NH 40 - 3	Bagmati (Kathmandu)	Tokha Municipality - 2	Villi panchetar tokha	27.781317	85.325226	50	Chandeshw ari1
83	EVCS/3300305/NH 17 - 02	Bagmati (Dhading)	Gajuri Gaunpalika - 5	Pida	27.804258	84.905675	160, 579, 583, 578, 582, 580, 584, 581, 566, 567, 189, 163	Pida2chha_ Dhading
84	EVCS/4760106/NH 72 - 1	Gandaki (Nawalparasi_E)	Binayee Tribeni Gaunpalika - 6	Tribeni	27.464556	83.939911	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
85	EVCS/4760414/NH 01 - 41	Gandaki (Nawalparasi_E)	Devchuli Municipality - 14	Devachuli	27.668845	84.186868	454, 556, 275, 1, 47, 5	nawalparas i_pragatina gar_2b
86	EVCS/4380103/NH 17 - 06	Gandaki (Tanahu)	Anbukhaireni Gaunpalika - 3	Aanbu Khaireni	27.903874	84.535595	322, 1656, 0, 324, 3154, 2520, 2793, 323, 2504	SatrasayaA abu6
87	EVCS/4390602/NH 47 - 5	Gandaki (Syangja)	Galyang Municipality - 2	Jagatradevi	27.947618	83.6804	1835, 1863, 1869, 1868, 1867, 1866, 1865, 1778, 3061, 1836, 1864	Jagatradevi 8
88	EVCS/4380201/NH 17 - 07	Gandaki (Tanahu)	Bandipur Gaunpalika - 1	Ghansikuwa	27.971263	84.399335	1200, 180, 1133, 1140, 1132, 1135, 1201, 0	Maiwal4
89	EVCS/4381002/NH 17 - 09	Gandaki (Tanahu)	Shuklagandaki Municipality - 2	Shuklagandaki	28.063075	84.070191	611, 1411, 0, 1799, 613, 615, 1410	Udendhung a1
90	EVCS/4400432/NH 17 - 10	Gandaki (Kaski)	Pokhara Lekhnath Metropolitan - 32	Lekhnath	28.1231	84.090715	7188, 3486, 7190, 6957, 6956, 7187, 7189, 713, 709, 4447	Rupakot1
91	EVCS/4390902/NH 47 - 8	Gandaki (Syangja)	Phedikhola Gaunpalika - 2	Phedi Khola	28.176681	83.892518	566, 571, 572, 1970, 1969, 2482, 564, 562	Phedikhola 9
92	EVCS/4400414/NH 17 - 13	Gandaki (Kaski)	Pokhara Lekhnath Metropolitan - 14	PIA Parking Pokhara	28.189368	84.013748	-	-
93	EVCS/4440307/NH 03 - 12	Gandaki (Parbat)	Kushma Municipality - 7	Shivalaya chowk Kushma	28.217755	83.68388	306	Sivalaya4

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
94	EVCS/4430103/NH 48 - 2	Gandaki (Myagdi)	Annapurna Gaunpalika - 3	Dana	28.531135	83.649994	147, 182	Dana
95	EVCS/5500410/NH 50 - 3	Lumbini (Kapilbastu)	Kapilbastu Municipality - 10	Banaganga	27.608254	83.131881	214, 215, 218, 552	Tenuwa majephe dar at
96	EVCS/5500302/NH 01 - 47	Lumbini (Kapilbastu)	Buddhabhumi Municipality - 2	Buddhabatika	27.660773	83.035838	509, 512, 505, 508, 507, 504, 3716, 503, 1215, 1651, 1649, 1264, 1650, 498, 3715, 1265	Budhdhi
97	EVCS/5491105/NH 01 - 45	Lumbini (Rupandehi)	Sainamaina Municipality - 5	Sainamaina	27.688443	83.33401	-	-
98	EVCS/5490109/NH 01 - 44	Lumbini (Rupandehi)	Butwal Sub- Metropolitan - 9	Butwal Bus Park	27.695226	83.464279	5	Butawal11
99	EVCS/5560609/NH 01 - 51	Lumbini (Dang)	Lamahi Municipality - 9	Satbariya	27.910637	82.333135	874	Chailahi2c ha
100	EVCS/5510503/NH 09 - 21	Lumbini (Arghakhanchi)	Sandhikharka Municipality - 3	Sandhikharka buspark	27.977755	83.126996	-	-
101	EVCS/5520104/NH 19 - 3	Lumbini (Pyuthan)	Ayirabati Gaunpalika - 4	Dhuwang	28.035478	82.864669	562, 653, 655, 654, 839, 869, 868	Dhunuwa3
102	EVCS/5570705/NH 58 - 2	Lumbini (Banke)	Nepalgunj Sub- Metropolitan - 5	Nepalgunj Bus Park	28.066656	81.637314	101	Nepalgunj6
103	EVCS/5460302/NH 71 - 3	Lumbini (Gulmi)	Dhurkot Gaunpalika - 2	Pipaldhara	28.08163	83.136317	814, 547, 523, 520, 522, 517	Pipaldhara 5
104	EVCS/5460907/NH 49 - 1	Lumbini (Gulmi)	Musikot Municipality - 7	Wamitaksar	28.177417	83.285733	983, 1612, 133, 1460, 1611	Wamitaksa r

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
105	EVCS/5580103/NH 05 - 06	Lumbini (Bardiya)	Badhaiyatal Gaunpalika - 3	Mainapokhar	28.177792	81.489667	-	-
106	EVCS/5580209/NH 01 - 56	Lumbini (Bardiya)	Bansagadhi Municipality - 9	Bansgadhi, Deudakala	28.269731	81.469198	161, 302, 303, 304, 305, 301	Deudakala 3
107	EVCS/6550403/NH 56 - 2	Karnali (Salyan)	Darma Gaunpalika - 3	Bhalchaur	28.562253	82.293825	91, 1953, 94, 96, 1954, 1955	Bhalchaur- 1
108	EVCS/6590301/NH 58 - 6	Karnali (Surkhet)	Birendranagar Municipality - 1	Bangesimal	28.608476	81.580591	17	Bayalkanda 2
109	EVCS/6590105/NH 09 - 25	Karnali (Surkhet)	Barahtal Gaunpalika - 5	Kunathari	28.716472	81.50364	-	-
110	EVCS/6610712/NH 57 - 2	Karnali (Jajarkot)	Tribeni Nalagad Municipality - 12	Bhagawati	28.912118	82.504409	-	-
111	EVCS/6610102/NH 56 - 3	Karnali (Jajarkot)	Barekot Gaunpalika - 2	Rokayagaun	28.948706	82.238077	157, 409	Rokayagau 7
112	EVCS/7711102/NH 01 - 58	Sudur Pashchim (Kailali)	Lamkichuha Municipality - 2	Lamki Chuha	28.630312	81.145188	941, 1413, 944	Baliya8_1
113	EVCS/7710601/NH 01 - 60	Sudur Pashchim (Kailali)	Ghodaghodi Municipality - 1	Ghodaghodi	28.676108	80.958921	-	-
114	EVCS/7720204/NH 05 - 02	Sudur Pashchim (Kanchanpur)	Belauri Municipality - 4	Belauri	28.680012	80.369688	288, 229, 247, 181, 230, 1	Sripur4
115	EVCS/7710407/NH 05 - 04	Sudur Pashchim (Kailali)	Dhangadhi Sub- Metropolitan - 7	manehara	28.689287	80.633336	0, 2	Dhangadhi 12

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
116	EVCS/7710413/NH 66 - 2	Sudur Pashchim (Kailali)	Dhangadhi Sub- Metropolitan - 13	Rajpur	28.745673	80.565225	962, 93, 687, 684, 779, 780, 935, 934, 960, 91, 961	Geta9
117	EVCS/7720502/NH 01 - 65	Sudur Pashchim (Kanchanpur)	Krishnapur Municipality - 2	Bani Bazar	28.858164	80.424762	1257, 73, 1436, 1435, 156, 164, 7, 1592, 1381, 1383, 1591, 1590, 162, 757, 1434, 759, 1255, 1254	Krishnapur 2
118	EVCS/7720911/NH 01 - 66	Sudur Pashchim (Kanchanpur)	Shuklaphanta Municipality - 11	Jhalari Pipaldhi	28.902898	80.355439	1865, 85, 2424	Jhalari9
119	EVCS/7720103/NH 01 - 67	Sudur Pashchim (Kanchanpur)	Bedkot Municipality - 3	Daijee	28.937853	80.279436	14	Daiji1
120	EVCS/7720401/NH 01 - 68	Sudur Pashchim (Kanchanpur)	Bhimdatta Municipality - 1	Bhasi Kanchanpur	28.963792	80.206683	2974, 1752, 1699, 1698, 2972, 2973, 4156, 1753, 611, 4157, 2975, 4459, 4589, 803, 1754, 3520, 4590	Mahendran agar1
121	EVCS/7730701/NH 67 - 1	Sudur Pashchim (Dadeldhura)	Parashuram Municipality - 1	salaun	29.135316	80.38031	45	Sirshe8thha
122	EVCS/7670210/NH 63 - 1	Sudur Pashchim (Bajura)	Budhiganga Municipality - 10	Kushkot	29.310863	81.276344	144, 186, 176	Barbis4
123	EVCS/7670301/NH 63 - 2	Sudur Pashchim(Bajura)	Budhinanda Municipality - 1	Kolti	29.504555	81.672244	7	Kolti1

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
<b>Phase-III</b>								
1	EVCS/150214/NH0 8 - 01	Koshi (Morang)	Biratnagar Metropolitan - 14	Biratnagar	26.407724	87.271164	1653, 1654, 1655, 1139, 1140, 254, 0, 585	Jatuwa3gha
2	EVCS/151406/NH0 5 - 35	Koshi (Morang)	Ratuwamai Municipality - 6	Sijuwa	26.44636	87.612878	147	Sijuwa8
3	EVCS/141001/NH7 3 - 1	Koshi (Jhapa)	Jhapa Gaunpalika - 1	Kumarkhod	26.450674	87.859626	584, 536, 484, 480, 482, 585, 535, 830	Kumarkho d2
4	EVCS/140301/NH0 2 - 1	Koshi (Jhapa)	Bhadrapur Municipality - 1	Bhadrapur	26.458676	88.070468	365, 123, 124, 367, 366, 364, 1, 6, 0	Prithbinaga r7
5	EVCS/141003/NH0 5 - 37	Koshi (Jhapa)	Jhapa Gaunpalika - 3	Rangeli Rd Taghandubba	26.48063	87.857223	7, 51, 52, 69	Taghandup pa3
6	EVCS/160206/NH0 5 - 33	Koshi (Sunsari)	Barju Gaunpalika - 6	Chimadi	26.486556	87.196245	1, 89	Chimdi5
7	EVCS/140905/NH0 5 - 38	Koshi (Jhapa)	Haldibari Gaunpalika - 5	Jalthal	26.505147	87.978507	30002, 3428, 8, 3429	Haldibari1 ka
8	EVCS/160605/NH0 8 - 04	Koshi (Sunsari)	Duhabi Municipality - 5	Duhabi	26.568272	87.279452	26, 0, 226	Duhabi7
9	EVCS/141006/NH7 3 - 2	Koshi (Jhapa)	Jhapa Gaunpalika - 6	Sharanamati	26.577817	87.892156	772, 1034	Sharanmati 6
10	EVCS/140603/NH7 6 - 1	Koshi (Jhapa)	Damak Municipality - 3	Baghkor Chowk	26.715029	87.680893	-	-
11	EVCS/140501/NH0 9 - 02	Koshi (Jhapa)	Buddhashanti Gaunpalika - 1	Budhabare	26.748039	88.032521	4632, 2092, 1490, 1491, 1492, 61, 2090	Buddabare 3
12	EVCS/141402/NH0 9 - 01	Koshi (Jhapa)	Mechinagar Municipality - 2	Bahundangi	26.753838	88.150253	30128, 30013, 676	Bahundang i6

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
13	EVCS/1140106/NH 12 - 1	Koshi (Udayapur)	Belaka Municipality - 6	Katunjebawala	26.874724	87.053231	14, 13, 12	KatunjeBa wala4
14	EVCS/131004/NH1 1 - 1	Koshi (Ilam)	Suryodaya Municipality - 4	Shree Antu	26.895749	88.125368	312, 126, 69	SriAntu
15	EVCS/130405/NH7 4 - 1	Koshi (Ilam)	Illam Municipality - 5	Barbote	26.965014	87.919838	355	Barbote4ng a
16	EVCS/180502/NH0 3 - 22	Koshi (Terhathum)	Myanglung Municipality - 2	Putali Bazar	27.133362	87.532082	245	Sabala1
17	EVCS/1100203/NH 03 - 20	Koshi (Bhojpur)	Arun Gaunpalika - 3	Pyauli	27.209799	87.154696	293, 999974, 325, 411	Pyauli6
18	EVCS/1130801/NH 75 - 3	Koshi (Khotang)	Rawa Besi Gaunpalika - 1	Kubinde	27.292544	86.720221	661, 1364	Kubhinde5
19	EVCS/1110702/NH 23 - 1	Koshi (Solukhumbu)	Solududhakunda Municipality - 2	Dudhakunda	27.58124	86.546414	50, 51, 49, 8	beni4_1591 525
20	EVCS/2151011/NH 05 - 30	Madhesh (Saptari)	Khadak Municipality - 11	Banauli	26.575675	86.626691	-	-
21	EVCS/2160303/NH 05 - 29	Madhesh (Siraha)	Bariyarpatti Gaunpalika - 3	Bariyarpatti	26.624168	86.33703	-	-
22	EVCS/2161608/NH 20 - 2	Madhesh (Siraha)	Siraha Municipality - 8	Siraha	26.663782	86.222237	-	-
23	EVCS/2170305/NH 05 - 27	Madhesh (Dhanusha)	Bideha Municipality - 5	Ekarahi Bideha	26.682356	86.082068	344, 112, 354	ekarahi2
24	EVCS/2181006/NH 28 - 2	Madhesh (Mahottari)	Manra Siswa Municipality - 6	Sarpallo	26.741825	85.778932		

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
25	EVCS/2171021/NH 26 - 1	Madhesh (Dhanusha)	Janakpur Sub- Metropolitan - 21	Dhanuaha	26.755403	85.900033	2000, 484, 192, 1917, 1916, 1433, 1926, 1448, 1927, 1439, 1441, 184, 483, 2073	Kuthan9
26	EVCS/2180207/NH 05 - 24	Madhesh (Mahottari)	Balwa Municipality - 7	Balawa	26.769713	85.810446	-	-
27	EVCS/2171402/NH 29 - 1	Madhesh (Dhanusha)	Mithila Bihari Municipality - 2	Mithileshwor Nikas	26.797285	86.003842	679, 681, 590, 680, 591	MithileshM auhahi1
28	EVCS/2181407/NH 05 - 23	Madhesh (Mahottari)	Samsi Gaunpalika - 7	Shamsi	26.810822	85.737965	-	-
29	EVCS/2190208/NH 05 - 19	Madhesh (Sarlahi)	Balara Municipality - 8	Gadahiyabairi	26.82352	85.40168	564, 541, 240, 252, 251, 881, 880, 255, 541, 486	Gadiya
30	EVCS/2170603/NH 30 - 1	Madhesh (Dhanusha)	Dhanusadham Municipality - 3	Dhanusadham	26.834818	86.059787	981, 829, 831, 837, 980, 830, 828	Tejnagar
31	EVCS/2321803/NH 36 - 2	Madhesh (Rautahat)	Yemunamai Gaunpalika - 3	Rajpur Tulsi	26.844178	85.284742	-	-
32	EVCS/2191901/NH 05 - 22	Madhesh (Sarlahi)	Parsa Gaunpalika - 1	Sangrampur	26.859205	85.665465	629, 997, 1050, 204, 1051, 26, 14, 996, 13	Chhaughar _Sangramp ur
33	EVCS/2191602/NH 05 - 20	Madhesh (Sarlahi)	Kaudena Gaunpalika - 2	Fulparasi	26.86227	85.485132	892, 104, 940, 1049, 894, 1048,	Phulparasi
34	EVCS/2160911/NH 80 - 1	Madhesh (Siraha)	Karjanha Municipality - 11	Karjanha	26.868227	86.190203	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
35	EVCS/2330106/NH 05 - 18	Madhesh (Bara)	Adarshkotwal Gaunpalika - 6	Paterwa Chowk	26.927771	85.158158	386, 343, 327, 345, 344, 346, 326	Partewa_2- 400ft
36	EVCS/2330612/NH 35 - 1	Madhesh (Bara)	Kalaiya Sub- Metropolitan - 12	Dharma Nagar	26.968188	84.976146	881, 773, 565, 56	Dharmanag ar_3(400Ft )
37	EVCS/2330902/NH 05 - 17	Madhesh (Bara)	Mahagadhimai Municipality - 2	Mahagadhimai	26.979212	85.044359	-	-
38	EVCS/2171311/NH 24 - 1	Madhesh (Dhanusha)	Mithila Municipality - 11	Tulsi Chauda	27.014462	85.926116	100, 130, 299, 48, 47, 239	Benga dawar
39	EVCS/2191717/NH 01 - 27	Madhesh (Sarlahi)	Lalbandi Municipality - 17	Raniganj	27.041761	85.669486	431, 1041, 1040, 1042, 206, 1005, 432	Jabadi9nga
40	EVCS/2340703/NH 05 - 14	Madhesh (Parsa)	Jirabhawani Gaunpalika - 3	Jeetpur	27.18571	84.72834	-	-
41	EVCS/2331010/NH 33 - 1	Madhesh (Bara)	Nijgadh Municipality - 10	Nijgadh	27.230657	85.155628	-	-
42	EVCS/3310418/NH 09 - 15	Bagmati (Makawanpur)	Hetauda Sub- Metropolitan - 18	Hetauda - Phaparbari Rd	27.365869	85.160925	3777, 3776, 3898, 2066	Hatiya8
43	EVCS/3350503/NH 05 - 12	Bagmati (Chitawan)	Madi Municipality - 3	Basantpur Bazar Madi	27.455166	84.319691	9	Baghanda3
44	EVCS/3310302/NH 41 - 4	Bagmati (Makawanpur)	Bhimphedi Gaunpalika - 2	Nibuwatar	27.53125	85.045539	-	-
45	EVCS/3350126/NH 77 - 3	Bagmati (Chitawan)	Bharatpur Metropolitan - 26	Dibyanagar	27.615241	84.241062	86, 146, 742, 743	Siswar4
46	EVCS/3350106/NH 44 - 1	Bagmati (Chitawan)	Bharatpur Metropolitan - 6	Bharatpur	27.616339	84.389359	89	Gitanagar1

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
47	EVCS/3240507/NH 34 - 08	Bagmati (Kabhrepalancho k)	Dhulikhel Municipality - 7	Dhulikhel	27.618722	85.553842	544, 545, 546, 522, 1, 55, 518, 538, 537, 521	Dhulikhel2
48	EVCS/3220205/NH 23 - 2	Bagmati (Dolakha)	Bhimeshwor Municipality - 5	Tamakoshi Dolkha	27.625131	86.074099	763, 764, 1353, 1352, 733	mati8- 1581368
49	EVCS/3311003/NH 41 - 5	Bagmati (Makawanpur)	Thaha Municipality - 3	Thaha	27.632945	85.084238	98, 508, 504, 864, 119, 508, 504, 865, 79	Shikharkot
50	EVCS/3250506/NH 15 - 1	Bagmati (Lalitpur)	Mahalaxmi Municipality - 6	Siddhipur	27.650508	85.356103	327, 278, 313, 314	Sanagau9k a
51	EVCS/3250415/UR - 05	Bagmati (Lalitpur)	Lalitpur Metropolitan - 15	Satdobato	27.654763	85.322022	368, 378, 369, 364, 371, 362, 363, 372	Lalitpur5yn a
52	EVCS/3260305/NH 34 - 03	Bagmati (Bhaktapur)	Madhyapur Thimi Municipality - 5	Bhat-Bhateni Thimi	27.675297	85.397571	-	-
53	EVCS/3311011/NH 41 - 6	Bagmati (Makawanpur)	Thaha Municipality - 11	Tistung Deurali	27.679327	85.084632	93, 92	Metrangsea mless
54	EVCS/3270804/NH 39 - 09	Bagmati (Kathmandu)	Nagarjun Municipality - 4	Swayambhu	27.713435	85.282037	131, 132, 82, 54, 88	Kalanki15
55	EVCS/3270806/NH 21 - 1	Bagmati (Kathmandu)	Nagarjun Municipality - 6	Nagarjun Ramkot	27.723421	85.247852	723, 724, 725, 726, 730, 727, 732, 733, 735, 491, 2301, 1586, 1585, 2314, 2307, 731	Dadapawa9
56	EVCS/3300206/NH 21 - 3	Bagmati (Dhading)	Dhunibesi Municipality - 6	Dharke Naubise	27.734909	85.13526	19, 612, 611, 610	Naubise1

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
57	EVCS/3270603/NH 39 - 05	Bagmati (Kathmandu)	Kathmandu Metropolitan - 3	Bhat-Bhateni Maharajgunj	27.739286	85.339252	92, 28, 4, 2, 7, 4, 175	Kathamand u3
58	EVCS/3300103/NH 17 - 03	Bagmati (Dhading)	Benighat Rorang Gaunpalika - 3	Bichbazar Benighat	27.808249	84.834486	618, 613, 857, 856, 858, 619, 1389, 793, 620, 99999	Benighat6k a_Dhading
59	EVCS/3230904/NH 03 - 16	Bagmati (Sindhupalchok)	Melamchi Municipality - 4	musure	27.821526	85.495213	181, 182, 179, 178, 175, 180, 177	Thakani
60	EVCS/3280202/NH 42 - 3	Bagmati (Nuwakot)	Bidur Municipality - 2	Nuwakot Sadak Bidur	27.908734	85.145403	1079, 3512, 4707, 255, 4708, 296, 1080	Bidur1
61	EVCS/3300908/NH 43 - 1	Bagmati (Dhading)	Nilakantha Municipality - 8	Nilkantha	27.909138	84.88348	146, 6, 9967	Murali Bhanjyan_ Dhading
62	EVCS/4760814/NH 68 - 1	Gandaki (Nawalparasi_E)	Madhyabindu Municipality - 14	Mainaghat	27.656915	83.994286	2812, 3891, 2813	Hupsekot
63	EVCS/4760504/NH 09 - 16	Gandaki (Nawalparasi_E)	Gaidakot Municipality - 4	Gaindakot	27.708597	84.40583	4566, 7077, 3753, 6677, 6523	Gaidakot
64	EVCS/4760203/NH 09 - 17	Gandaki (Nawalparasi_E)	Bulingtar Gaunpalika - 3	Bulingtar Rd Upallo Arkhale	27.840292	84.17785	1416, 1415, 330, 331, 328, 1010, 1011, 1095, 326, 771	Bulingtar
65	EVCS/4760302/NH 09 - 18	Gandaki (Nawalparasi_E)	Bungdikali Gaunpalika - 2	Dedgaun	27.856635	84.080478	300, 3231, 1230, 1231, 292, 3421, 3422	Rakuwa
66	EVCS/4390506/NH 69 - 1	Gandaki (Syangja)	Chapakot Municipality - 6	Sankhar	27.880342	83.917081	2004, 441, 969, 441, 2005	Sankhar8

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
67	EVCS/4390502/NH 69 - 2	Gandaki (Syangja)	Chapakot Municipality - 2	Chapakot	27.892154	83.814526	3853, 3619, 144, 3852, 4250, 4249	Chapakot3
68	EVCS/4380406/NH 45 - 1	Gandaki (Tanahu)	Bhimad Municipality - 6	Bhimad	27.972093	84.087222	219, 1020, 1019, 1018, 1035, 1036, 1161, 1034, 1154, 1162, 218, 932, 635	Bhimad1
69	EVCS/4380406/NH 68 - 2	Gandaki (Tanahu)	Bhimad Municipality - 6	Bhimad	27.978385	84.074589	926, 1564, 2340, 925, 924, 14, 2339, 1563, 22, 318, 28	Bhimad1
70	EVCS/4360109/NH 44 - 4	Gandaki (Gorkha)	Aarughat Gaunpalika - 9	Ghyampesal - Aarughat Marg Tandrang	28.047617	84.814979	908, 6	Aaruchana ute1
71	EVCS/4391004/NH 70 - 1	Gandaki (Syangja)	Putalibazar Municipality - 4	Syangja- Sataun Road Putalibazar	28.107821	83.878515	-	-
72	EVCS/4370807/NH 03 - 14	Gandaki (Lamjung)	Sundarbazar Municipality - 7	Sundarbazar	28.126665	84.41814	21, 1, 727, 541	Sundarbaza r4
73	EVCS/4400409/NH 17 - 14	Gandaki (Kaski)	Pokhara Lekhnath Metropolitan - 9	Pokhara Bus Park	28.208047	83.986464	77, 98, 97, 96	Pokhara9
74	EVCS/4450503/NH 03 - 10	Gandaki (Baglung)	Galkot Municipality - 3	Harichaur	28.213552	83.409912	683, 520, 523, 630, 623, 621	Hatiya1
75	EVCS/4370108/NH 25 - 1	Gandaki (Lamjung)	Besishahar Municipality - 8	Besisaha	28.223454	84.379614	4358, 250, 4359, 279, 1152, 4356, 277, 266	Besishahar 9

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
76	EVCS/4459999/NH 52 - 5	Gandaki (Baglung)	Dhorpatan Hunting Reserve Hunting Reserve - 99	Syalpakhe	28.47826	83.045732	-	-
77	EVCS/4420104/NH 48 - 3	Gandaki (Mustang)	Barhagaun Muktikhsetra Gaunpalika - 4	Kagbeni	28.835575	83.78506	225, 223, 226, 224, 227	Kagbeni8k ha
78	EVCS/5490613/NH 52 - 1	Lumbini (Rupandehi)	Lumbini Sanskritik Municipality - 13	Lumbini Sanskritik	27.419728	83.226297	-	-
79	EVCS/5491313/NH 47 - 1	Lumbini (Rupandehi)	Siddharthanagar Municipality - 13	Siddharthanagar	27.502368	83.45697	185, 27, 26, 20, 23, 22, 186, 10	Siddarthan agar5New
80	EVCS/5500402/NH 50 - 2	Lumbini (Kapilbastu)	Kapilbastu Municipality - 2	Taulihawa Bus Park	27.540785	83.052259	419, 423	Kapilbastu na pa
81	EVCS/5500509/NH 05 - 08	Lumbini (Kapilbastu)	Krishnanagar Municipality - 9	Bahadurganj	27.545955	82.840676	128, 1375, 129, 1096	Bahadurgu nj3
82	EVCS/5480411/NH 46 - 1	Lumbini (Nawalparasi_W)	Ramgram Municipality - 11	Jamuwad	27.549559	83.683892	379, 554, 555, 589, 587, 503, 586, 584	Jamuwad
83	EVCS/5491607/NH 47 - 2	Lumbini (Rupandehi)	Tillotama Municipality - 7	Tilottama	27.603624	83.47338	1267, 1268, 595, 776, 594, 593	Karahiya3k ha
84	EVCS/5491110/NH 52 - 3	Lumbini (Rupandehi)	Sainamaina Municipality - 10	Saljhundi	27.719727	83.252222	144, 1475, 618, 1476, 131, 127, 617, 1782, 1477, 126, 125, 1479, 1480, 1481	Gajedi1ka

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
85	EVCS/5560407/NH 05 - 07	Lumbini (Dang)	Gadhawa Gaunpalika - 7	Gadhawa	27.812668	82.536045	756	Gadhawa1 ka
86	EVCS/5510610/NH 71 - 1	Lumbini (Arghakhanchi)	Sitganga Municipality - 10	Siddhara	27.840033	82.976554	-	-
87	EVCS/5470703/NH 09 - 19	Lumbini (Palpa)	Rampur Municipality - 3	Rampur	27.867272	83.928264	1828, 3851, 2150, 2012, 1000, 0	Darchha1
88	EVCS/5510407/NH 52 - 4	Lumbini (Arghakhanchi)	Panini Gaunpalika - 7	Chibek	27.919262	83.221049	-	-
89	EVCS/5461101/NH 09 - 20	Lumbini (Gulmi)	Ruru Gaunpalika - 1	Ridi Bazaar Ruru	27.937399	83.434044	173, 59, 58, 25, 16	Ruru6
90	EVCS/5560609/NH 55 - 1	Lumbini (Dang)	Lamahi Municipality - 9	Satbariya	27.970994	82.211869	-	-
91	EVCS/5510106/NH 19 - 2	Lumbini (Arghakhanchi)	Bhumekasthan Municipality - 6	Khilji	27.993075	83.0139	-	-
92	EVCS/5461206/NH 49 - 2	Lumbini (Gulmi)	Satyawati Gaunpalika - 6	Khaireni	28.01977	83.436473	973, 2104, 974, 1539	Johang5
93	EVCS/5570716/NH 58 - 1	Lumbini (Banke)	Nepalgunj Sub- Metropolitan - 16	Nepalgunj	28.029356	81.606397	56, 1009, 54, 1008, 1007, 477, 834, 1006, 1081, 591, 479, 1082, 1083	Jaisapur
94	EVCS/5510303/NH 71 - 2	Lumbini (Arghakhanchi)	Malarani Gaunpalika - 3	Khanadaha	28.057629	83.118116	-	-
95	EVCS/5520704/NH 09 - 22	Lumbini (Pyuthan)	Pyuthan Municipality - 4	New bazar jumri Pyuthan	28.100241	82.850452	1486, 4783, 1651, 4906, 4905, 4781, 4782, 1658, 581	Bijuwa7
96	EVCS/5460304/NH 71 - 4	Lumbini (Gulmi)	Dhurkot Gaunpalika - 4	Dhurkot Rajasthal	28.105906	83.147407	622, 623, 625, 624, 147	DhurkotRa sthal

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
97	EVCS/5520904/NH 53 - 2	Lumbini (Pyuthan)	Sworgadwary Municipality - 4	Gothiwan	28.120431	82.73182	895, 152, 150, 670, 787, 669, 695, 203, 19	Gothiwan5
98	EVCS/5561005/NH 09 - 23	Lumbini (Dang)	Tulsipur Sub- Metropolitan - 5	Tulsipur Bus park	28.132746	82.293116	543	Tulsipur5
99	EVCS/5560105/NH 09 - 24	Lumbini (Dang)	Babai Gaunpalika - 5	Purandhara	28.192343	82.122763	-	-
100	EVCS/5570105/NH 01 - 54	Lumbini (Banke)	Baijanath Gaunpalika - 5	S	28.202187	81.626105	2128, 2586, 533, 402, 999976, 403, 2127, 2587	Bankatawa 7
101	EVCS/5530804/NH 53 - 3	Lumbini (Rolpa)	Suwarnabati Gaunpalika - 4	Mijhing	28.246583	82.727748	328, 2041	Mijhing7
102	EVCS/5530404/NH 53 - 4	Lumbini (Rolpa)	Rolpa Municipality - 4	Liwang	28.295702	82.639426	2751, 2750, 315, 316, 92	Liwanga6
103	EVCS/5530406/NH 54 - 2	Lumbini (Rolpa)	Rolpa Municipality - 6	Darbot	28.327975	82.53947	800, 34, 35	Kotgau6
104	EVCS/5530903/NH 54 - 3	Lumbini (Rolpa)	Thawang Gaunpalika - 3	Thawang	28.474364	82.654925	258, 259	mirul5
105	EVCS/6550902/NH 27 - 1	Karnali (Salyan)	Sharada Municipality - 2	Hanumandhoka	28.375782	82.161152	506, 507, 215, 214, 206, 35	Khalanga-4
106	EVCS/6550102/NH 56 - 1	Karnali (Salyan)	Bagchaur Municipality - 2	Tharmare	28.453298	82.277804	2442, 526	Tharmare-4
107	EVCS/6590212/NH 58 - 4	Karnali (Surkhet)	Bheriganga Municipality - 12	Chhinchu Dobato	28.458843	81.71938	9, 11, 12, 123, 126	Lekhaparaj ul8gya

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
108	EVCS/6590906/NH 57 - 1	Karnali (Surkhet)	Simta Gaunpalika - 6	Rakam	28.556689	82.004419	2, 5, 7, 6, 319, 89, 87, 326	Rakam1
109	EVCS/6590307/NH 60 - 1	Karnali (Surkhet)	Birendranagar Municipality - 7	Siddhapaila	28.611395	81.628193	40	Bijayashwa ri4
110	EVCS/6540405/NH 55 - 4	Karnali (Rukum_W)	Musikot Municipality - 5	Musikot	28.624622	82.460824	1499, 623	Khalanga3
111	EVCS/6540301/NH 03 - 09	Karnali (Rukum_W)	Chaurjahari Municipality - 1	Bijayashwari	28.637504	82.198963	1054, 1055	Bijayashwa ri4
112	EVCS/6600606/NH 60 - 2	Karnali (Dailekh)	Dungeshwor Gaunpalika - 6	Tallo Dungeshwar	28.762337	81.663487	2, 999999	Dadaparaju 17
113	EVCS/6590806/NH 09 - 26	Karnali (Surkhet)	Panchpuri Municipality - 6	Babiyachaur	28.808864	81.390904	-	-
114	EVCS/6600505/NH 61 - 1	Karnali (Dailekh)	Dullu Municipality - 5	Dullu	28.857116	81.604347	1076, 567, 1045, 850, 508, 851	Dullu6
115	EVCS/6620710/NH 57 - 3	Karnali (Dolpa)	Thuli Bheri Municipality - 10	Mool Baato Dunai	28.953578	82.895944	-	-
116	EVCS/6600104/NH 58 - 7	Karnali (Dailekh)	Aathabis Municipality - 4	Rakam Karnali	29.054503	81.458287	9, 653, 652, 8, 648	Rakam karnali-4
117	EVCS/6640203/NH 61 - 2	Karnali (Kalikot)	Khandachakra Municipality - 3	Tadi Bzar Manma	29.138	81.614072	18, 340, 673, 677, 999989, 999990, 999973	Manma8
118	EVCS/6630107/NH 61 - 3	Karnali (Jumla)	Chandannath Municipality - 7	Chandannath	29.270715	82.170853	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
119	EVCS/6630405/NH 60 - 3	Karnali (Jumla)	Kanakasundari Gaunpalika - 5	Gothiujula sinja	29.411588	82.002332	-	-
120	EVCS/6650101/NH 60 - 4	Karnali (Mugu)	Chhayanath Rara Municipality - 1	New Road Gamgadhi	29.550786	82.147881	-	-
121	EVCS/7711301/NH 62 - 2	Sudur Pashchim (Kailali)	Tikapur Municipality - 1	Tikapur	28.517858	81.117396	1061, 1253, 1053, 1486, 2089, 2088, 1719, 1488, 3294, 3137, 1802, 0, 2390, 2442, 2388	Tikapur
122	EVCS/7711005/NH 05 - 05	Sudur Pashchim (Kailali)	Kailari Gaunpalika - 5	Pawera	28.552772	80.820619	33, 38, 221, 224, 223, 34	Pabera-7
123	EVCS/7720802/NH 05 - 03	Sudur Pashchim (Kanchanpur)	Punarbans Municipality - 2	Punarbans	28.665103	80.449154	161, 1	Kalika2
124	EVCS/7720208/NH 05 - 01	Sudur Pashchim (Kanchanpur)	Belauri Municipality - 8	Belauri	28.715648	80.312381	1037, 343	Rampurbila spur7
125	EVCS/7710708/NH 01 - 62	Sudur Pashchim (Kailali)	Godawari Municipality - 8	Syaule bazar	28.798054	80.623662	21	Sripur6
126	EVCS/7720505/NH 01 - 64	Sudur Pashchim (Kanchanpur)	Krishnapur Municipality - 5	Krishnapur	28.836452	80.485277	5	Krishnapur 5
127	EVCS/7710704/NH 66 - 3	Sudur Pashchim (Kailali)	Godawari Municipality - 4	Attariya, Godawari	28.876817	80.579916	-	-

S.N	EVCS_CODE	PROVINCE (District)	MP/RMP- Ward_No	Location	Latitude	Longitude	Plot No.	Sheet ID.
128	EVCS/7700502/NH 66 - 4	Sudur Pashchim (Doti)	Joroyal Gaunpalika - 2	Budar	29.089139	80.569978	316, 412, 139, 137	Chahara, ch atiyaun3
129	EVCS/7690904/NH 03 - 06	Sudur Pashchim (Achham)	Sanphebagar Municipality - 4	Sanphebagar	29.240862	81.218918	-	-
130	EVCS/7700401/NH 65 - 1	Sudur Pashchim (Doti)	Dipayal Silgadi Municipality - 1	Dipayal Silgadhi	29.274128	80.910168	-	-
131	EVCS/7740104/NH 03 - 01	Sudur Pashchim (Baitadi)	Dasharathchanda Municipality - 4	Dasharathchand a	29.552192	80.433019	-	-
132	EVCS/7680510/NH 64 - 1	Sudur Pashchim (Bajhang)	JayaPrithivi Municipality - 10	Jayaprithvi	29.555473	81.197612	1	Chainpur1
133	EVCS/7750505/NH 66 - 5	Sudur Pashchim (Darchula)	Mahakali Municipality - 5	Mohati	29.842345	80.541241	-	-

**Note:** Plot number "0" indicates government-owned or public land, while “-” denotes land recorded on a freesheet where official plot numbers are not available due to incomplete cadastral records in Nepal.

## 4.7 FINANCIAL ANALYSIS

### 4.7.1. PPP model/ Business model for implementation modality

The Public-Private Partnership (PPP)/ Business model framework in Nepal provides a flexible platform for collaboration between government entities and private sector stakeholders in infrastructure development, including Electric Vehicle Charging Stations (EVCS). The shareholding structure and allocation of responsibilities between public and private partners critically influence project governance, risk-sharing, and operational efficiency. Below is a detailed description of four PPP models tailored to Nepal's context, incorporating the responsible agencies involved in each.

#### PPP Models and Responsible Agencies

PPP Model	Public Share	Private Share	Responsible Agencies
<b>Model 1 (Independent)</b>	100%	0%	Federal Government of Nepal (GoN), Provincial Governments, Local Governments, NEA
<b>Model 2 (Independent)</b>	0%	100%	Manufacturers, Suppliers, Charging Point Operators (CPO), Line Owners
<b>Model 3 (Integrated)</b>	51%	49%	Federal, Provincial, Local Governments; Manufacturers, Suppliers, CPO, Line Owners
<b>Model 4 (Integrated)</b>	49%	51%	Manufacturers, Suppliers, CPO, Line Owners; Federal, Provincial, Local Governments

#### **Model 1: Fully Public Ownership (100% Public Share)**

This model places full ownership, financing, and operational responsibility with government bodies at federal, provincial, and local levels. It ensures maximum public control, strategic alignment with national EV and clean energy policies, and equitable access. However, it may face constraints in mobilizing capital, operational efficiency, and rapid deployment due to limited government resources and capacity. This model is suitable for pilot projects, rural or underserved areas, and projects of high strategic importance where public interest is paramount.

#### **Model 2: Fully Private Ownership (100% Private Share)**

Under this model, private entities such as manufacturers, suppliers, Charging Point Operators (CPOs), and electricity line owners (e.g., Nepal Electricity Authority) take full responsibility for investment, construction, operation, and maintenance of EVCS infrastructure. This approach can accelerate infrastructure rollout, foster innovation, and optimize operational efficiency. However, it requires robust regulatory frameworks to ensure service quality, affordability, and alignment with public policy. The government's role is primarily regulatory and facilitative.

#### **Model 3: Public Majority (51% Public / 49% Private)**

This hybrid model balances public control with private sector participation. The government retains majority ownership and decision-making authority, ensuring alignment with national

development goals and public welfare. Private partners contribute capital, technology, and operational expertise. This structure is ideal for projects where the government wants to maintain strategic oversight while leveraging private sector efficiencies. It also facilitates risk-sharing and encourages private investment under government stewardship.

#### **Model 4: Private Majority (49% Public / 51% Private)**

Here, private entities hold the majority share, leading project implementation, financing, and operations, while the government retains a significant minority share to safeguard public interests and provide regulatory oversight. This model is suitable for commercially viable EVCS projects in urban or high-traffic corridors where private investment and innovation can be maximized. The government's involvement ensures policy coherence, risk mitigation, and public accountability.

#### **Institutional and Governance Considerations**

- **Federal, Provincial, and Local Governments** play critical roles in policy formulation, regulatory oversight, land acquisition, and facilitating inter-agency coordination. They also participate as equity holders in Models 1 and 3, and minority partners in Model 4.
- **Private Sector Entities** including manufacturers, suppliers, CPOs, and line owners are responsible for technology deployment, operation, maintenance, and customer service. Their participation is essential in Models 2, 3, and 4, bringing innovation, efficiency, and capital.
- **PPP Board and PPP Center:** Nepal has established institutional mechanisms such as the PPP Board of Directors and PPP Center to oversee project approval, coordination, and facilitation. These bodies ensure compliance with PPP policy, risk allocation, and stakeholder engagement across all models.

#### **Conclusion**

The selection of an appropriate PPP model for Nepal's EVCS master plan should be guided by project scale, strategic importance, risk profile, and market maturity:

- **Model 1** is appropriate for foundational or strategic projects requiring full government control and public welfare prioritization.
- **Model 2** suits commercially viable, high-demand areas where private sector-led rapid deployment and innovation are feasible.
- **Model 3** offers a balanced approach for pilot projects or critical infrastructure where government oversight and private efficiency must coexist.
- **Model 4** is optimal for scaling up EVCS networks in competitive markets, leveraging private majority investment with government oversight.

Implementing these models requires strengthening Nepal's PPP legal framework, enhancing institutional capacity, and ensuring transparent governance. Clear contracts with defined risk-sharing, performance benchmarks, and revenue arrangements are essential to attract private investment while safeguarding public interests. This multi-model approach will enable Nepal to effectively expand EV charging infrastructure, supporting its sustainable transport and clean energy ambitions.

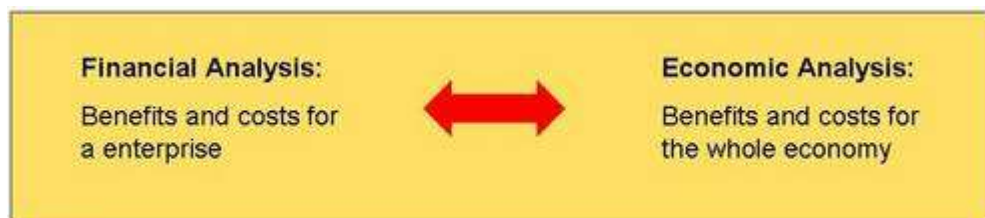
## 4.7.2. Financial Analysis

### 4.7.2.1 Background

To justify investment in the projects, generally total cost streams incurred by project through its lifetime period are compared with total returns from project operation period. This analysis in technical term defined as cost benefit analysis (CBA). CBA uses total costs to the project in which some are direct costs, those can be measured in monetary term, and other are indirect costs, also known as intangible cost, these cannot be measured directly in monetary term and need some justifiable valuation technique to present in monetary term. CBA also uses direct, tangible, benefits and indirect, intangible, benefits in analysis. Project invested from private sector for profit motive preferred to use CBA considering only direct cost and direct benefits into account and such analysis is known as financial analysis. In case of Government funded project CBA cannot be limit to the financial analysis only rather it is expected to be analyzed taking economic issues into consideration. In economic analysis intangible costs and benefits are taken into account for analysis in addition to the financial analysis. That is if indirect cost to the project and indirect benefits of the project are properly valued using some scientific technique and then are added to the respective streams of financial costs and financial benefits such streams of costs and benefits are known as economic cost and benefits of the projects. If these two streams of economic cost and benefits are compared using analytical tools then this is called economic analysis of the project.

#### Financial and economic viability and sustainability

Financial and economic analyses have similar features. Both estimate the net-benefits of a project investment based on the difference between the with-project and the without-project situations. The basic difference between them is that the financial analysis compares benefits and costs to the enterprise, while the economic analysis compares the benefits and costs to the whole economy.



Economic analysis is concerned with the true value a project holds for the society as a whole. It subsumes all members of society, and measures the project's positive and negative impacts. In addition, economic analysis would also cover costs and benefits of goods and services that are not sold in the market and therefore have no market price.

There are two more significant differences between financial and economic analysis. While financial analysis uses market prices to check the balance of investment and the sustainability of a project, economic analysis uses economic prices that are converted from the market price by excluding tax, profit, subsidy, etc. to measure the legitimacy of using national resources to certain projects. Financial and economic analyses also differ in their treatment of external effects (benefits and costs), such as favourable effects on health. Economic analysis attempts to value such externalities in order to reflect the true cost and value to the society. The inclusion of externalities raises difficult questions of their identification and measurement in terms of money.

Underlining the integrated perspective of the IFM approach, cost-benefit analysis in the present context, is meant to be a form of economic analysis.

However, it has to be noted that economic and financial analysis are also complementary. For a project to be economically viable, it must be financially sustainable. If a project is not financially sustainable, there will be no adequate funds to properly operate, maintain and replace assets. It has sometimes been suggested that financial viability should not be made a concern because as long as a project is economically sound, it can be supported through government subsidies.

### **Macro-economic impact of the Project**

Macroeconomics is the branch of economics that studies the behaviour and performance of an economy as a whole. It focuses on the aggregate changes in the economy such as unemployment, growth rate, gross domestic product and inflation. Macroeconomics analyses all aggregate indicators and the microeconomic factors that influence the economy. The two main areas of macroeconomic research are long-term economic growth and shorter-term business cycles. Government and corporations use macroeconomic models to help in formulating of economic policies and strategies. Macroeconomics deals with the performance, structure, and behaviour of the entire economy, in contrast to microeconomics, which is more focused on the choices made by individual actors in the economy (like people, households, industries, etc.).

Given the enormous scale of government budgets and the impact of economic policy on consumers and businesses, macroeconomics clearly concerns itself with significant issues. Properly applied, economic theories can offer illuminating insights on how economies function and the long-term consequences of particular policies and decisions. Macroeconomic theory can also help individual businesses and investors make better decisions through a more thorough understanding of the effects of broad economic trends and policies on their own industries.

It is also important to understand the limitations of economic theory. Theories are often created in a vacuum and lack certain real-world details like taxation, regulation, and transaction costs. The real world is also decidedly complicated and includes matters of social preference and conscience that do not lend themselves to mathematical analysis.

Even with the limits of economic theory, it is important and worthwhile to follow the major macroeconomic indicators like GDP, inflation, and unemployment. The performance of companies, and by extension their stocks, is significantly influenced by the economic conditions in which the companies operate and the study of macroeconomic statistics can help an investor make better decisions and spot turning points.

Likewise, it can be invaluable to understand which theories are in favour and influencing a particular government administration. The underlying economic principles of a government will say much about how that government will approach taxation, regulation, government spending, and similar policies. By better understanding economics and the ramifications of economic decisions, investors can get at least a glimpse of the probable future and act accordingly with confidence.

### **Distribution and Poverty impact analysis**

Distribution and poverty impact analyses show how benefits are dispersed. These analyses examine how different project designs or changes to related policies and institutional arrangements will affect the flow of net benefits to various stakeholders. Distribution and poverty impact analyses require thorough analysis of financial and economic cash flows for a given project. This calls for the accurate description of how inputs, costs, outputs, and benefits are identified and the corresponding values estimated.

Another key requirement is the proper identification of relevant stakeholders. This process can explain a project's likely impact on the poor and on the groups that may gain or lose as a result of the project. Distribution analysis could then be used to assess if a project gives stakeholders good reason to participate. Distribution analysis can also be used to evaluate how project-related pricing policies could affect the flow of net benefits. It also helps assess a project's sustainability.

In the present case of EVCS Master plan, economic analysis of the project includes direct and indirect costs and similar two streams of the benefit as explained below;

#### 4.7.2.2 Costs to the EVCS

**Direct Costs:** Direct costs are the tangible expenditure to the EVCS incurred during its construction. In addition to this it also includes spending that will make for its operation and regular and periodic maintenance. Construction costs are onetime cost to the project but operation and maintenance costs are series of cost those occur annually to the project for its lifetime. Detail listing of the cost type is presented below.

##### a) For Private Land

##### For Category-I Layout of EVCS

Table: Construction Cost

SN.	Description	Amount
1	Buildings and Infrastructures	33,28,000.00
2	DC Fast Charger (120 kW) (1no)	40,82,400.00
3	DC Fast Charger (60 kW) (4 no)	1,30,63,680.00
4	AC Level 2 Charger (7.4 Kw) (1no)	16,16,630.00
5	Insurance cost for chargers is 0.5% of the total charger cost	93,813.55
6	500 kVA PSS, TOD meter, and safety measures	55,00,000.00
7	Land Lease (10 years prepaid)	3,60,00,000.00
8	Security (CCTV, fencing, signage)	2,00,000.00
	<b>Total Amount (A)</b>	<b>6,38,84,523.55</b>
	<b>Miscellaneous Other Works @2% of (A)</b>	<b>12,77,690.47</b>
	<b>Price Adjustment Contingencies @ 10% of (A)</b>	<b>63,88,452.36</b>
	<b>Physical Contingencies @ 10% of (A)</b>	<b>63,88,452.36</b>
	<b>Vat @ 13% of (A)</b>	<b>99,65,985.67</b>
	<b>Grand Total</b>	<b>8,79,05,104.40</b>

**For Category-II Layout of EVCS**

Table: Construction Cost

<b>SN.</b>	<b>Description</b>	<b>Amount</b>
1	Buildings and Infrastructures	20,95,250.00
2	DC Fast Charger (60 kW) (4no)	1,30,63,680.00
3	AC Level 2 Charger (7.4 Kw) (1no)	16,16,630.00
4	Insurance cost for chargers is 0.5% of the total charger cost	73,401.55
5	500 kVA PSS, TOD meter, and safety measures	55,00,000.00
6	Land Lease (10 years prepaid)	2,40,00,000.00
7	Security (CCTV, fencing, signage)	2,00,000.00
	<b>Total Amount (A)</b>	<b>4,65,48,961.55</b>
	<b>Miscellaneous Other Works @2% of (A)</b>	<b>9,30,979.23</b>
	<b>Price Adjustment Contingencies @ 10% of (A)</b>	<b>46,54,896.16</b>
	<b>Physical Contingencies @ 10% of (A)</b>	<b>46,54,896.16</b>
	<b>Vat @ 13% of (A)</b>	<b>72,61,638.00</b>
	<b>Grand Total</b>	<b>6,40,51,371.09</b>

**For Category-III Layout of EVCS**

Table: Construction Cost

<b>SN.</b>	<b>Description</b>	<b>Amount</b>
1	Buildings and Infrastructures	12,94,750.00
2	DC Fast Charger (60 kW) (3 no)	97,97,760.00
3	500 kVA PSS, TOD meter, and safety measures	55,00,000.00
4	Land Lease (10 years prepaid)	1,44,00,000.00
5	Security (CCTV, fencing, signage)	1,00,000.00
	<b>Total Amount (A)</b>	<b>3,11,41,498.80</b>
	<b>Miscellaneous Other Works @2% of (A)</b>	<b>6,22,829.98</b>
	<b>Price Adjustment Contingencies @ 10% of (A)</b>	<b>31,14,149.88</b>
	<b>Physical Contingencies @ 10% of (A)</b>	<b>31,14,149.88</b>
	<b>Vat @ 13% of (A)</b>	<b>48,58,073.81</b>
	<b>Grand Total</b>	<b>4,28,50,702.35</b>

**b) For Public Land****For Category-I Layout of EVCS**

Table: Construction Cost

<b>SN.</b>	<b>Description</b>	<b>Amount</b>
1	Buildings and Infrastructures	33,28,000.00
2	DC Fast Charger (120 kW) (1no)	40,82,400.00
3	DC Fast Charger (60 kW) (4 no)	1,30,63,680.00
4	AC Level 2 Charger (7.4 Kw) (1no)	16,16,630.00
5	Insurance cost for chargers is 0.5% of the total charger cost	93,813.55
6	500 kVA PSS, TOD meter, and safety measures	55,00,000.00
7	Land Lease (10 years prepaid)	1,80,00,000.00
8	Security (CCTV, fencing, signage)	2,00,000.00

SN.	Description	Amount
	<b>Total Amount (A)</b>	<b>4,58,84,523.55</b>
	<b>Miscellaneous Other Works @2% of (A)</b>	<b>9,17,690.47</b>
	<b>Price Adjustment Contingencies @ 10% of (A)</b>	<b>45,88,452.36</b>
	<b>Physical Contingencies @ 10% of (A)</b>	<b>45,88,452.36</b>
	<b>Vat @ 13% of (A)</b>	<b>71,57,985.67</b>
	<b>Grand Total</b>	<b>6,31,37,104.40</b>

### For Category-II Layout of EVCS

Table: Construction Cost

SN.	Description	Amount
1	Buildings and Infrastructures	20,95,250.00
2	DC Fast Charger (60 kW) (4no)	1,30,63,680.00
3	AC Level 2 Charger (7.4 Kw) (1no)	16,16,630.00
4	Insurance cost for chargers is 0.5% of the total charger cost	73,401.55
5	500 kVA PSS, TOD meter, and safety measures	55,00,000.00
6	Land Lease (10 years prepaid)	1,20,00,000.00
7	Security (CCTV, fencing, signage)	2,00,000.00
	<b>Total Amount (A)</b>	<b>3,45,48,961.55</b>
	<b>Miscellaneous Other Works @2% of (A)</b>	<b>6,90,979.23</b>
	<b>Price Adjustment Contingencies @ 10% of (A)</b>	<b>34,54,896.16</b>
	<b>Physical Contingencies @ 10% of (A)</b>	<b>34,54,896.16</b>
	<b>Vat @ 13% of (A)</b>	<b>53,89,638.00</b>
	<b>Grand Total</b>	<b>4,75,39,371.09</b>

### For Category-III Layout of EVCS

Table: Construction Cost

SN.	Description	Amount
1	Buildings and Infrastructures	12,94,750.00
2	DC Fast Charger (60 kW) (3 no)	97,97,760.00
3	500 kVA PSS, TOD meter, and safety measures	55,00,000.00
4	Land Lease (10 years prepaid)	72,00,000.00
5	Security (CCTV, fencing, signage)	1,00,000.00
	<b>Total Amount (A)</b>	<b>2,39,41,498.80</b>
	<b>Miscellaneous Other Works @2% of (A)</b>	<b>4,78,829.98</b>
	<b>Price Adjustment Contingencies @ 10% of (A)</b>	<b>23,94,149.88</b>
	<b>Physical Contingencies @ 10% of (A)</b>	<b>23,94,149.88</b>
	<b>Vat @ 13% of (A)</b>	<b>37,34,873.81</b>
	<b>Grand Total</b>	<b>3,29,43,502.35</b>

**Indirect Costs:** In project implementation, not all costs can be included directly in balance sheet because of measurement and valuation difficulties, but impact of such intangible costs hamper project and society in multiple ways. However, such costs are not directly measurable in monetary term but number of literatures provide scientifically acceptable valuation techniques and so can be measures in terms of proxy money. Especially such indirect costs to EVPCS includes; increased pressure on local infrastructure such as schools, health centres, and roads due to congestion, foregone benefits like losses

in agricultural production, and greater demand on natural resources. Communities also bear additional time costs related to altered access and increased traffic. On the project side, indirect costs arise from resource supply challenges, changes in landscape, environmental degradation, waste generation, and market risks. Furthermore, socio-cultural impacts such as threats to local traditions, loss of traditional knowledge and skills, and potential shifts in food habits are significant considerations. To capture these effects comprehensively, indirect costs are estimated at 25% of the direct project costs, based on extensive consultations with stakeholders including experts, elected representatives, civil society members, and industry groups and supported by literature reviews. Incorporating these indirect costs ensures a more realistic and holistic economic analysis, which is critical for sustainable planning and implementation of EVCS infrastructure.

#### 4.7.2.3 Benefits of EVCS

##### 4.7.2.3A. Direct Benefits

The direct benefits of Electric Vehicle Charging Stations (EVCS) include revenue from DC fast and AC charging services, income from commercial spaces such as canteen-cafeterias, vehicle parking and washing fees, and advertisement board income. Additionally, utility charges for electricity, water, and waste management contribute to the revenue stream. These diverse income sources are expected to provide a stable and continuous cash flow throughout the EVCS's operational life, supporting maintenance and future expansion.

##### For Category-I Layout of EVCS

*Table: List of Direct Benefits to the EVCS (first year)*

S.No.	Description	Total Revenue per month	Remarks
1	Canteen-Cafeteria	4,40,000.00	
2	DC Fast Charging	15,55,200.00	
3	AC Charging	86,400.00	
4	Vehicle washing Center	1,35,000.00	
<b>Total Revenue per month</b>		<b>22,16,600.00</b>	
<b>Total Revenue per year</b>		<b>2,65,99,200.00</b>	

Source: Field Survey 2081/Engineering estimation

##### For Category-II Layout of EVCS

*Table: List of Direct Benefits to the EVCS (first year)*

S.No.	Description	Total Revenue per month	Remarks
1	Canteen-Cafeteria	3,00,000.00	
2	DC Fast Charging	10,36,800.00	
3	AC Charging	86,400.00	
4	Vehicle washing Center	1,35,000.00	
<b>Total Revenue per month</b>		<b>15,58,200.00</b>	
<b>Total Revenue per year</b>		<b>1,86,98,400.00</b>	

Source: Field Survey 2081/Engineering estimation

**For Category-III Layout of EVCS**

S.No.	Description	Total Revenue per month	Remarks
1	DC Fast Charging	7,80,000.00	
2	Vehicle washing center	1,35,000.00	
<b>Total Revenue per month</b>		<b>9,15,000.00</b>	
<b>Total Revenue per year</b>		<b>1,09,80,000.00</b>	

Source: Field Survey 2081/Engineering estimation

**4.7.2.3B Indirect Benefits**

When investment is made on project it creates two types of benefits: primary and secondary. Primary benefits are directly attributable to the project's outputs, such as increased availability of charging infrastructure and enhanced electric vehicle usage. Secondary benefits, while not directly linked to the project's immediate outputs, arise as consequential economic and social gains that would not materialize without the project. These indirect benefits, although not recorded on the project's balance sheet, contribute significantly to broader economic development and societal well-being. Due to the complexity of isolating project-specific impacts from overall economic growth, economists employ proxy indicators to estimate these benefits. For EVCS projects, such indicators include growth in transportation-related businesses, employment generation, market expansion, and improvements in supporting infrastructure such as roads, electricity, water supply, and communication networks. Additionally, secondary benefits manifest as increased agricultural productivity and household incomes in surrounding areas, job creation in ancillary markets, skill development, enhanced export potential, import substitution, attraction of foreign direct investment (FDI), increased capital formation through income diversion, reduced youth migration for employment, and more effective utilization of remittances. In the current framework, indirect benefits associated with EVCS development are conservatively estimated to equal 100% of the direct benefits. This valuation is grounded in comprehensive methodologies involving focus group discussions, key informant interviews, and consultations with experts, including educators, elected representatives, civil society members, environmentalists, chambers of commerce, hotel unions, industrial departments, and other relevant stakeholders, supported by extensive literature review on industrial and infrastructural development. Incorporating these secondary benefits into economic assessments ensures a holistic understanding of EVCS projects' transformative potential, thereby facilitating informed decision-making and sustainable infrastructure planning.

**4.7.2.4 Issues Considered in Analysis:**

- All regular costs and benefits are hiked by 10% in two years considering average inflation and other.
- Staff salaries reported in cost stream follows the government norms, and also includes allowance, insurance and one month extra in a year.
- Water, electricity, waste bill is reported with accordance of government norms.
- Valuation technique for indirect costs and benefits requires sufficient time on the top of humanitarian and financial resources. Due to shortage of time, here intangible benefits are derived in terms of percentage of financial costs and benefits and decision on percentage are based on discussion with stakeholder and team expertise.

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#### **4.7.2.5 Economic Analysis:**

In this segment all direct and indirect costs to the economy as a whole are compared with all benefits generated by project in the economy. Costs in the economic analysis includes; direct tangible cost to the project, intangible cost experienced by this project and cost incurred by surrounding economy due to presence of EVCS. In cost stream foregone benefits/production of surrounding economy also included. Similarly, economic benefits to the project include all direct benefits to the EVCS and benefits achieved by society in presence of this project. Employment generation in secondary market, increase in income of local households, change in local sectoral production, increase in availability of infrastructure, skill enhancement of Labor, access to multiple service to local people, FDI, Export, Import, remittance, foreign employment and other positive backward and forward linkages are economic benefits generated by the project. Similar to the financial analysis, here economic costs are compared with economic benefits using tools; benefit costs ratio (BCR), internal rate of return (IRR) and payback period. Analysis of the parameter based upon following assumptions;

- EVCS will be operating for 30 years after construction completion.
- Construction period of the project will be of One Years.
- Operation and maintenance costs are expected to grow at 10% in every two years and so grow benefit generated from the project.
- Study uses discount rate 10% (used by government funded project in Nepal and this rate average of inflation in Nepal and discount rate of World Bank and ADB).
- Sensitivity analysis is carried out for higher discounting rate equal to 12% as private sector in one the stakeholder and which lend money from bank and the lending rate of commercial banks given by Nepal Rastra Bank is equal to twelve percent
- Percentage of occupancy status between 50 to 75% for potentiality of increment in revenue generation from project located in city and town area.
- Land is supposed to made available on a lease basis, i.e. so land rental price is included in parameter calculation.
- Project will be operating at maximum 95% occupancy.
- Annual maintenance cost is estimated as half percent of capital expenditure and periodic maintenance at every five years is estimated as three percent of initial construction cost.
- Due to computation difficulties, indirect costs and benefits are reported in terms of percentage of direct cost and benefits to the projects.
- Congestion cost, resource sharing cost, extra time cost, production foregone cost, and other invisible costs altogether estimated equal to 25% of annual operation and maintenance cost of the project.
- Access to the newly developed infrastructure, employment generation inside SEZ and in secondary market, market activity expansion, increase in agriculture production, and increase in income opportunity are indirect benefits generated by project and are expected to generate value at least three to five fold of benefits generated inside SEZ. Due to limitation indirect benefits to the projects are assumed equal 100% of annual benefit of project.
- Indirect benefits such as improved access to newly developed infrastructure, employment generation both within the EVCS facilities and in related secondary markets, expansion of market activities, and enhanced income opportunities for surrounding communities are significant. These indirect benefits are typically estimated to generate economic value at least three to five times greater than the direct benefits realized within the EVCS itself. However, due to practical limitations in precise quantification, the indirect benefits for the EVCS project are conservatively assumed to be equal to 100% of the project's annual direct benefits, ensuring a balanced and realistic valuation in economic assessments

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#### 4.7.2.6 Financial and Economic Outcome:

##### a) For Private Land

Streams of costs and benefits for 30 years, life time, additional to the construction period of the EVCS are estimated. Cash flow for both; costs and benefits with intangible components and costs and benefits without intangible components are discounted by 10% factor to obtain present value of respective streams and are presented in Annex XIII. The financial analysis shows that the EVCS project is not financially viable on its own, with financial benefit-cost ratios of 0.94, 0.90, and 0.81 for Category-I, II, and III layouts, respectively, and FIRRs below the 10% discount rate. This is mainly due to high upfront investment costs, low initial utilization, limited profit margins from regulated tariffs, and a lack of additional revenue streams. However, when broader socioeconomic and environmental benefits such as avoided emissions, better air quality, energy security, and job creation are included, the project becomes economically feasible. The economic BCRs rise to 1.74, 1.65, and 1.49, and the economic IRRs reach 29.95%, 28.10%, and 23.75% for each layout, indicating clear net benefits to society. Result indicate that EVCS project is feasible in economic sense. Variability in the parameter results are also tested for higher discounting rate 12% discounting rate used by ADB and WB in project and average lending rate of the commercial bank, the opportunity cost of capital, analysis in Nepal.

##### b) For Public Land

Streams of costs and benefits for 30 years, life time, additional to the construction period of the EVCS are estimated. Cash flow for both; costs and benefits with intangible components and costs and benefits without intangible components are discounted by 10% factor to obtain present value of respective streams and are presented in Annex XIII. The financial analysis shows that the EVCS project is financially viable on its own, with financial benefit-cost ratios of 1.03 for Category-I and Category- II, III is not viable with financial benefit ratios of 0.97, 0.87 layouts, respectively, and FIRRs above the 10% discount rate for Category-I and Category-II, Category-III is below 10% discount rate. This is mainly due to high upfront investment costs, low initial utilization, limited profit margins from regulated tariffs, and a lack of additional revenue streams. However, when broader socioeconomic and environmental benefits such as avoided emissions, better air quality, energy security, and job creation are included, the project becomes economically feasible. The economic BCRs rise to 1.88, 1.77 and 1.59 and the economic IRRs reach 38.26%, 34.96% and 28.73% for each layout, indicating clear net benefits to society. Result indicate that EVCS project is feasible in economic sense. Variability in the parameter results are also tested for higher discounting rate 12% discounting rate used by ADB and WB in project and average lending rate of the commercial bank, the opportunity cost of capital, analysis in Nepal.

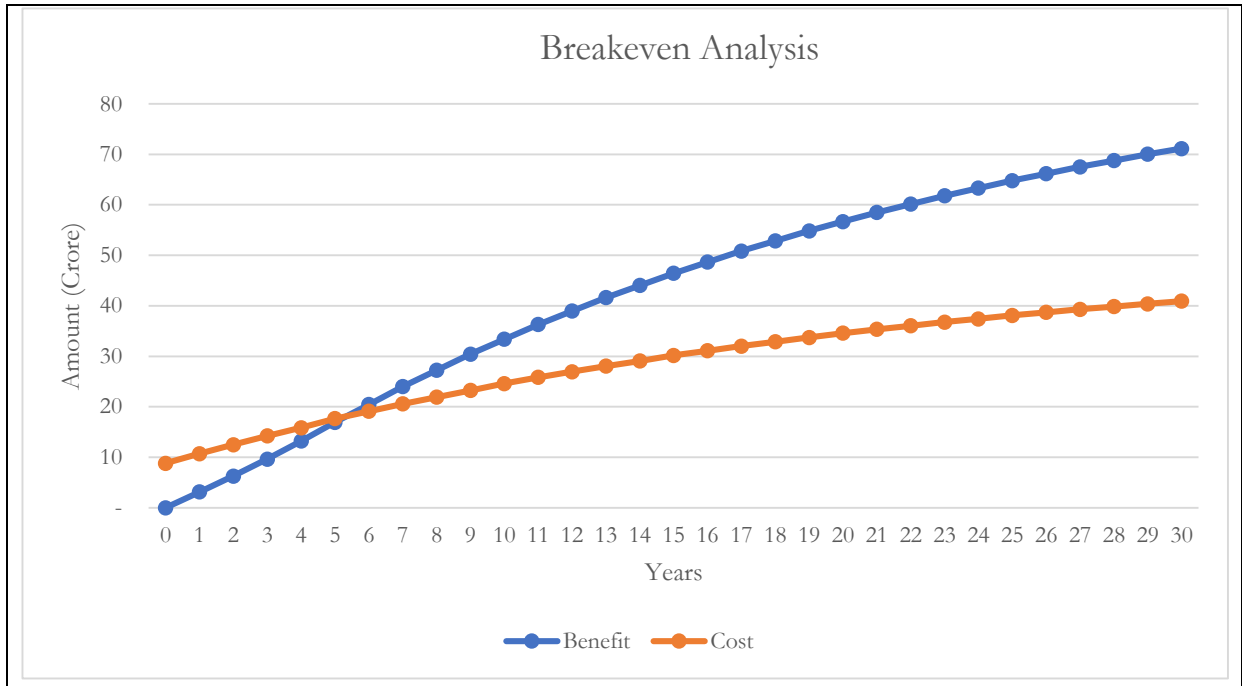
#### 4.7.2.7 Break-Even Analysis

Study also analysed for payback period of the investment made. In this regard, analysis is made for finding number of years when return from project surpasses the project investment including its regular investment and the point of time when return equate costs also known as breakeven point for the project. Both series of costs and benefits are normalized for time factors with discounting rate applied in the study. Following chart represent the breakeven analysis for the project. X-axis represents number of year or lifetime of the project and Y-axis stand for amount of return in ten million NPR.

##### a) For Private Land

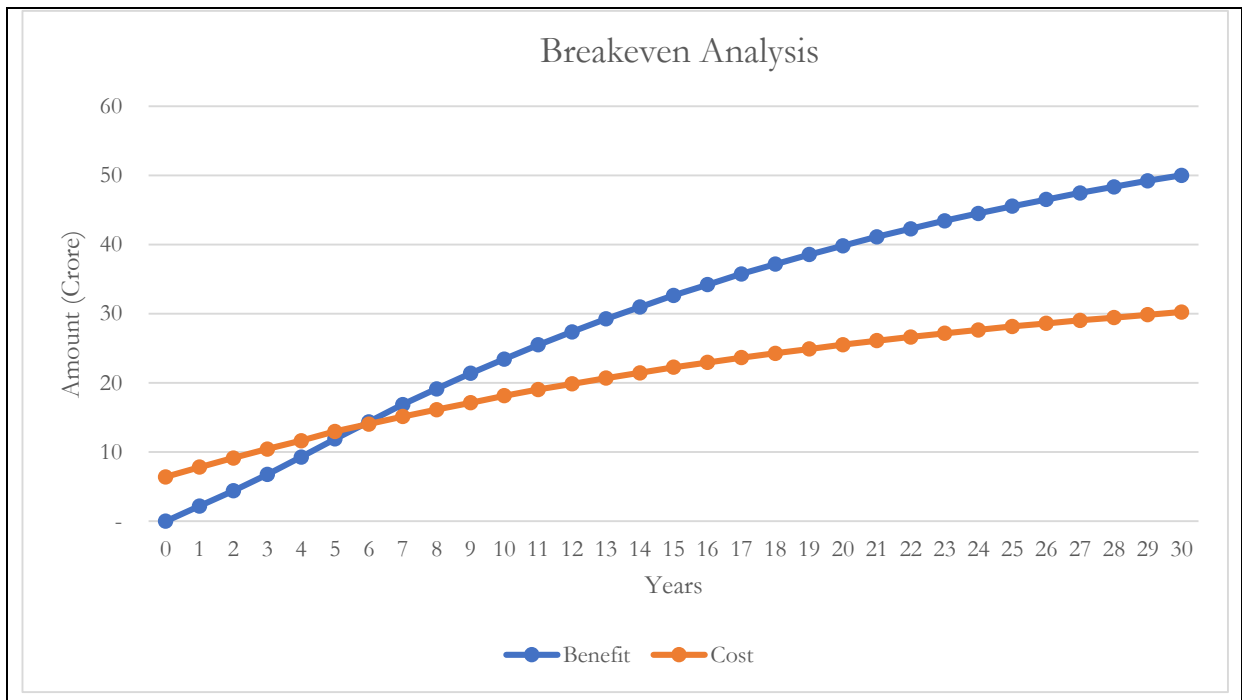
##### For Category –I layout of EVCS

Clearly the graph for return from the project intersects cost line at the point lies between year 5 & 6 and for the monetary value between 10 and 20 crores. Indicate that the payback period for the project investment is less than 6 years after construction.



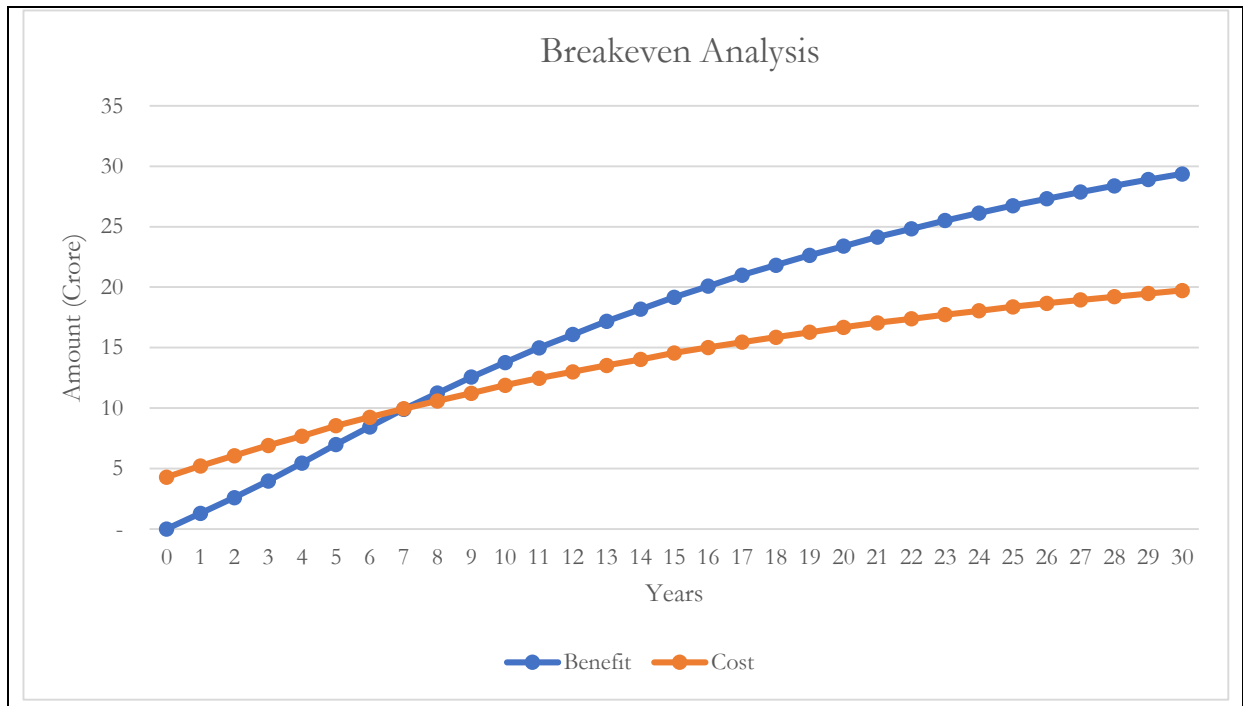
**For Category –II layout of EVCS**

Clearly the graph for return from the project intersects cost line at the point lies between year 5 & 6 and for the monetary value between 10 and 20 crores. Indicate that the payback period for the project investment is less than 6 years after construction.



**For Category –III layout of EVCS**

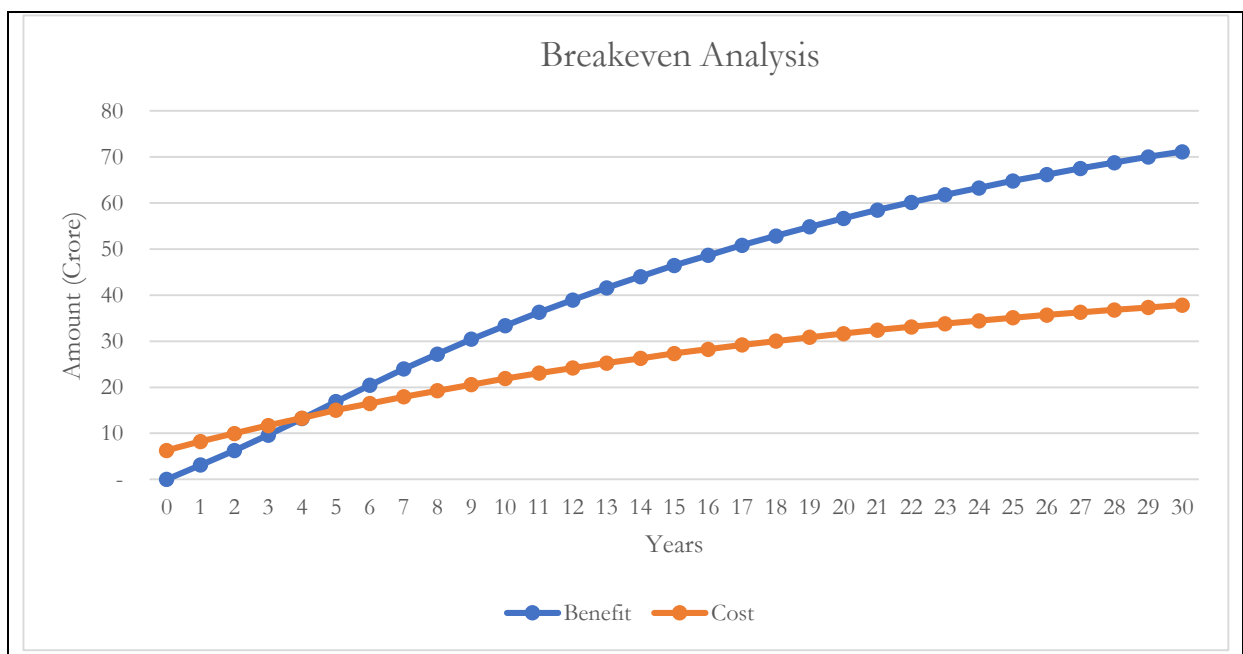
Clearly the graph for return from the project intersects cost line at the point lies between year 7 & 8 and for the monetary value between 5 and 10 crores. Indicate that the payback period for the project investment is less than 8 years after construction.



**b) For Public Land**

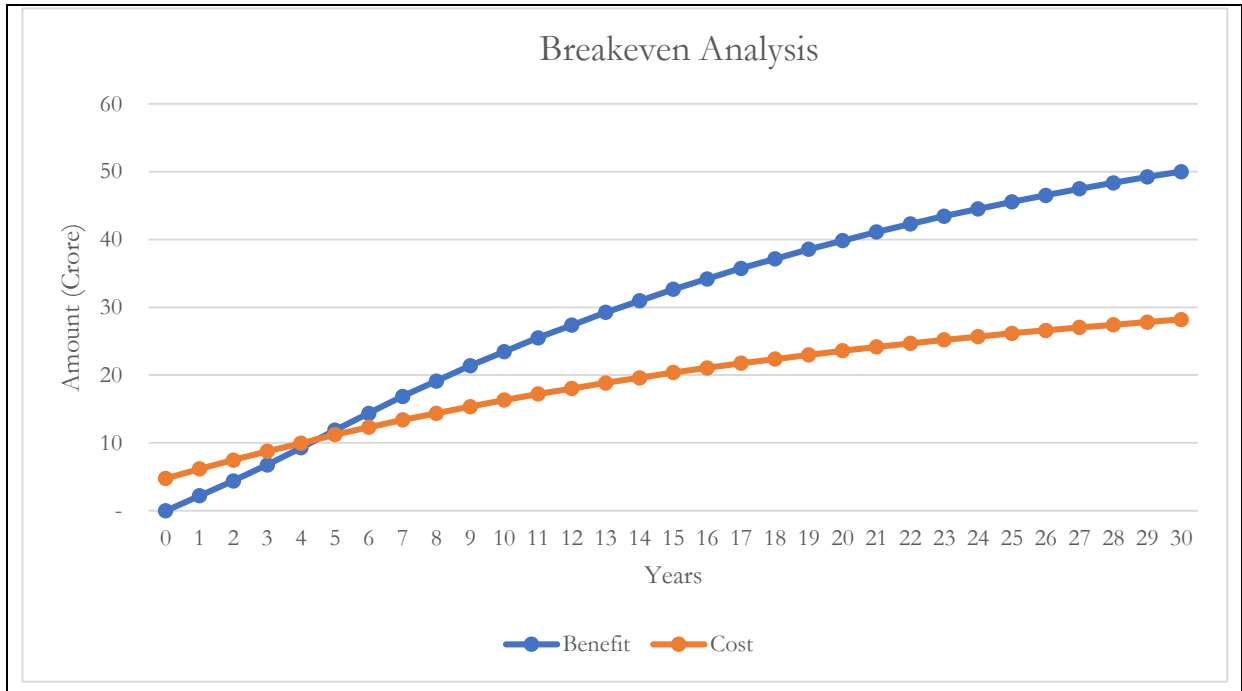
**For Category –I layout of EVCS**

Clearly the graph for return from the project intersects cost line at the point lies between year 4 & 5 and for the monetary value between 10 and 20 crores. Indicate that the payback period for the project investment is less than 5 years after construction.



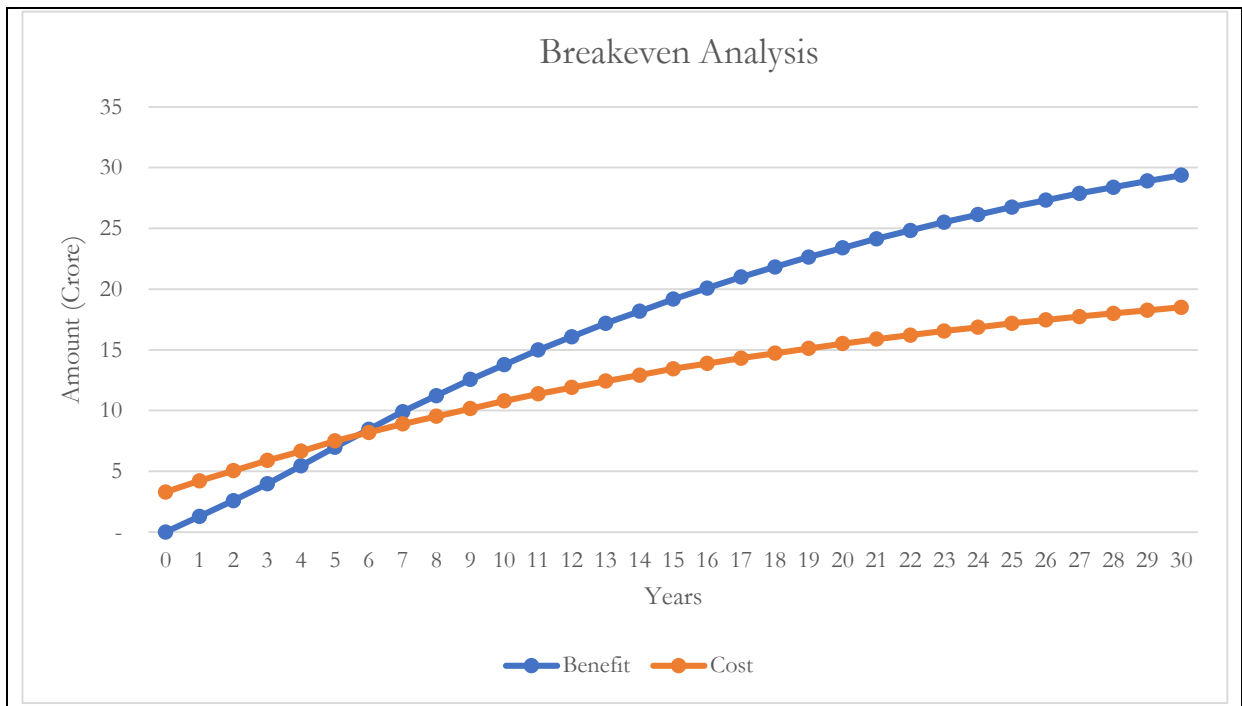
**For Category –II layout of EVCS**

Clearly the graph for return from the project intersects cost line at the point lies between year 4 & 5 and for the monetary value between 5 and 15 crores. Indicate that the payback period for the project investment is less than 5 years after construction.



**For Category –III layout of EVCS**

Clearly the graph for return from the project intersects cost line at the point lies between year 5 & 6 and for the monetary value between 5 and 10 crores. Indicate that the payback period for the project investment is less than 6 years after construction.



#### 4.7.2.8 Sensitivity Analysis

In addition to this outcome, parameter sensitivity is tested considering higher discounting rate. Main objective behind conducting sensitivity is that whether this project needs subsidiary support from the government or if government can generate additional income from EVCS. Sensitivity analysis for project is presented in table below.

##### a) For Private Land

##### For Category –I layout of EVCS

*Table: Sensitivity Analysis of the EVCS project*

S. N.	Condition	BCR	IRR %
<b>Discounting Rate = 10%</b>			
1	Normal	1.74	29.95
2	10% ↑ in construction cost	1.70	28.00
3	10% ↑ in O&M cost	1.61	27.92
4	10% ↑ in const. and exp.	1.58	26.13
5	10% ↓ in Project return	1.56	25.74
6	10% ↑ in const. and exp. and 10% ↓ in Project return	1.42	22.20
<b>Discounting Rate = 12%</b>			
1	Normal		17.74
2	10% ↑ in construction cost		17.52
3	10% ↑ in O&M cost		17.50
4	10% ↑ in const. and exp.		17.26
5	10% ↓ in Project return		17.20
6	10% ↑ in const. and exp. and 10% ↓ in Project return		16.54

##### For Category –II layout of EVCS

*Table: Sensitivity Analysis of the EVCS project*

S. N.	Condition	BCR	IRR %
<b>Discounting Rate = 10%</b>			
1	Normal	1.65	28.10
2	10% ↑ in construction cost	1.62	26.29
3	10% ↑ in O&M cost	1.53	26.02
4	10% ↑ in const. and exp.	1.50	24.37
5	10% ↓ in Project return	1.49	23.99
6	10% ↑ in const. and exp. and 10% ↓ in Project return	1.35	20.52
<b>Discounting Rate = 12%</b>			

S. N.	Condition	BCR	IRR %
1	Normal		17.53
2	10% ↑ in construction cost		17.28
3	10% ↑ in O&M cost		17.24
4	10% ↑ in const. and exp.		16.97
5	10% ↓ in Project return		16.90
6	10% ↑ in const. and exp. and 10% ↓ in Project return		16.13

### For Category –III layout of EVCS

Table: Sensitivity Analysis of the EVCS project

S. N.	Condition	BCR	IRR %
<b>Discounting Rate = 10%</b>			
1	Normal	1.49	23.75
2	10% ↑ in construction cost	1.46	22.24
3	10% ↑ in O&M cost	1.38	21.69
4	10% ↑ in const. and exp.	1.35	20.33
5	10% ↓ in Project return	1.34	19.98
6	10% ↑ in const. and exp. and 10% ↓ in Project return	1.22	16.73
<b>Discounting Rate = 12%</b>			
1	Normal		16.86
2	10% ↑ in construction cost		16.55
3	10% ↑ in O&M cost		16.43
4	10% ↑ in const. and exp.		16.09
5	10% ↓ in Project return		15.99
6	10% ↑ in const. and exp. and 10% ↓ in Project return		14.86

From table it is clear that BCR for all category is greater than one and IRR is greater than discount rate for condition applied, implied that project is feasible in all of the conditions at ten percent discounting rate, however, project seen sensitive for simultaneous increase in cost and decrease in return with higher discounting rate.

### b) For Public Land

#### For Category –I layout of EVCS

S. N.	Condition	BCR	IRR %
<b>Discounting Rate = 10%</b>			
1	Normal	1.88	38.26
2	10% ↑ in construction cost	1.85	35.73

S. N.	Condition	BCR	IRR %
3	10% ↑ in O&M cost	1.74	35.55
4	10% ↑ in const. and exp.	1.71	35.25
5	10% ↓ in Project return	1.69	32.75
6	10% ↑ in const. and exp. and 10% ↓ in Project return	1.54	28.16
<b>Discounting Rate = 12%</b>			
1	Normal		18.39
2	10% ↑ in construction cost		18.23
3	10% ↑ in O&M cost		18.20
4	10% ↑ in const. and exp.		18.03
5	10% ↓ in Project return		17.99
6	10% ↑ in const. and exp. and 10% ↓ in Project return		17.51

**For Category –II layout of EVCS**

*Table: Sensitivity Analysis of the EVCS project*

S. N.	Condition	BCR	IRR %
<b>Discounting Rate = 10%</b>			
1	Normal	1.77	34.96
2	10% ↑ in construction cost	1.74	32.68
3	10% ↑ in O&M cost	1.64	32.28
4	10% ↑ in const. and exp.	1.61	30.23
5	10% ↓ in Project return	1.60	29.76
6	10% ↑ in const. and exp. and 10% ↓ in Project return	1.45	25.41
<b>Discounting Rate = 12%</b>			
1	Normal		18.17
2	10% ↑ in construction cost		17.99
3	10% ↑ in O&M cost		17.94
4	10% ↑ in const. and exp.		17.75
5	10% ↓ in Project return		17.70
6	10% ↑ in const. and exp. and 10% ↓ in Project return		17.13

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**For Category –III layout of EVCS**
*Table: Sensitivity Analysis of the EVCS project*

S. N.	Condition	BCR	IRR %
<b>Discounting Rate = 10%</b>			
1	Normal	1.59	28.73
2	10% ↑ in construction cost	1.56	26.91
3	10% ↑ in O&M cost	1.47	26.21
4	10% ↑ in const. and exp.	1.44	24.59
5	10% ↓ in Project return	1.43	24.16
6	10% ↑ in const. and exp. and 10% ↓ in Project return	1.30	20.29
<b>Discounting Rate = 12%</b>			
1	Normal		17.59
2	10% ↑ in construction cost		17.36
3	10% ↑ in O&M cost		17.25
4	10% ↑ in const. and exp.		17.00
5	10% ↓ in Project return		16.92
6	10% ↑ in const. and exp. and 10% ↓ in Project return		16.06

From table it is clear that BCR for all category is greater than one and IRR is greater than discount rate for condition applied, implied that project is feasible in all of the conditions at ten percent discounting rate, however, project seen sensitive for simultaneous increase in cost and decrease in return with higher discounting rate.

#### 4.7.2.9 Master Plan Total Cost

The number of Electric Vehicle Charging Stations (EVCS) in the master plan is based on initial assumptions from strategic assessments and preliminary studies. The plan includes 179 Category-I, 183 Category-II, and 62 Category-III stations to address infrastructure gaps and promote EV adoption. These figures will be refined as detailed planning progresses. The total estimated investment for deploying all 424 EVCS units is approximately NPR 25.57 billion for Private land scenario and NPR 3.31 billion for Public land scenario. The cost breakdown is as follows:

##### a) For Private Land

Category	Number of EVCS	Unit Cost (NPR)	Total Cost (NPR)
Category-I	148	8,79,05,104.40	13,00,99,55,451.20
Category-II	160	6,40,51,371.09	10,24,82,19,374.40
Category-III	54	4,28,50,702.35	2,31,39,37,926.90
<b>Total</b>	362		25,57,21,12,752.50

##### a) For Public Land

Category	Number of EVCS	Unit Cost (NPR)	Total Cost (NPR)
Category-I	31	6,31,37,104.40	1,95,72,50,236.40
Category-II	23	4,75,39,371.09	1,09,34,05,535.07
Category-III	8	3,29,43,502.35	26,35,48,018.80
<b>Total</b>	62		3,31,42,03,790.27

Note: Based on the field assessment, the deployment plan for Electric Vehicle Charging Stations (EVCS) identifies a total of 424 stations, of which 362 are located on private land and 62 on public land.

This comprehensive investment reflects Nepal's commitment to establishing a robust and sustainable EV charging infrastructure across the country.

#### 4.7.2.10 Justification of EVCS

Electric Vehicle Charging Stations (EVCS) serve as critical infrastructure that supports the transition to sustainable transportation by facilitating widespread adoption of electric vehicles. By providing reliable and accessible charging services, EVCS attract investment in clean technologies and innovation, contributing to foreign direct investment (FDI) inflows and reducing reliance on fossil fuel imports, thereby improving the trade balance. The development of EVCS stimulates local economic growth through job creation in installation, operation, and maintenance, while also fostering skill development and entrepreneurship among local youth. Additionally, EVCS promote the commercialization of renewable energy and related industries, enhancing value addition within the region and reducing transportation costs associated with conventional fuel supply chains. Collectively, these benefits position EVCS as a strategic asset for economic development, environmental sustainability, and technological advancement.

#### 4.7.2.11 Financing EVCS Project

Nepal faces capital shortages for infrastructure projects, including EV charging stations (EVCS). With federalization, large projects fall under the federal government, while smaller initiatives are managed by provincial and local governments. To address funding gaps and accelerate EVCS deployment, Nepal can utilize the following capital sources:

- **Foreign Direct Investment (FDI):** Attracts international expertise and capital, especially from countries with advanced EV sectors.
- **Bilateral and Multilateral Agencies:** Institutions like ADB and World Bank provide grants, soft loans, and technical support for green infrastructure.
- **Domestic Financial Institutions:** Local banks and financial bodies can offer loans, green bonds, and innovative finance products.
- **Government Funding (Federal, Provincial, Local):** All levels can provide co-financing, policy incentives, and infrastructure support.
- **Public-Private Partnerships (PPP)/ Business model:** Combines public sector support with private sector efficiency and investment, ideal for high-traffic corridors.

Public-Private Partnerships (PPP) are particularly suitable for Nepal's EV charging infrastructure development, especially along high-traffic corridors like the East-West Highway and major urban centres. The federal and provincial governments can provide regulatory support, land, and initial funding, while private investors bring technical expertise, operational efficiency, and additional capital. This collaboration helps mitigate financial risks, accelerates project implementation, and ensures

sustainable management. Given Nepal's limited public funds and growing demand for EV infrastructure, PPPs offer a practical and effective model to expand charging networks rapidly and efficiently.

By leveraging these diverse funding sources, Nepal can overcome capital constraints and accelerate the rollout of EV charging infrastructure, supporting sustainable transport and economic growth.

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## CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

### 5.1 CONCLUSIONS

#### 5.1.1 Preparation of Standards and Guidelines for Public Charging Infrastructure

The adoption of electric mobility in Nepal requires a structured and harmonized approach to the development of public charging infrastructure. In the absence of nationally defined technical and operational standards, stakeholders face inconsistencies in system design, installation, interoperability, and service quality. While international best practices offer a useful reference, they must be adapted to Nepal's unique geographical, infrastructural, and policy environment. A comprehensive framework is necessary to guide classification of chargers, tariff structures, and user safety protocols.

This study concludes that developing context-specific standards and guidelines is foundational to establishing a reliable and scalable EV charging network. Clear operational policies, transparent licensing procedures, and enforceable technical specifications will provide clarity to developers, users, and regulators. The adoption of uniform standards will accelerate infrastructure deployment, ensure long-term safety and performance, and foster public and private sector confidence in Nepal's transition to electric mobility.

#### 5.1.2 Safety Standards Required for the Grid and EV Charging Infrastructure

Safety is a critical component of EV charging infrastructure, especially as it interacts directly with the national electrical grid and the general public. Nepal's exposure to natural hazards such as floods, earthquakes, and landslides and increase in road accident involving EV vehicles further elevates the need for robust safety mechanisms. Furthermore, recent observations indicate a noticeable rise in EV related road accidents which has raised public concerns about vehicle safety, emergency response preparedness, and the need for roadside safety infrastructure such as lighting and signage at charging points. Without enforceable safety standards and inspection protocols, infrastructure failures may pose significant risks to users, operators, and the surrounding environment.

This study concludes that a formalized safety standard adapted to Nepal's hazard profile is essential for grid-connected EV charging systems. Key components include earth fault protection, surge protection, emergency disconnection, fire resistance, and structural resilience. Regular audits, certification of installation personnel, and adherence to international codes (e.g., IEC) will strengthen the resiliability and safety of the charging network and protect both users and infrastructure.

#### 5.1.3 Regulations Regarding Connectivity with the Grid

As EV charging stations are integrated into the national grid, they introduce new technical challenges such as peak loads, voltage fluctuations, and harmonic distortions especially with

high capacity fast chargers. Without regulatory oversight, uncoordinated grid connections may reduce system efficiency and increase the risk of power disruptions, particularly during high demand periods.

The study emphasizes the need for a regulatory framework that governs grid connectivity for EV infrastructure. Key technical parameters such as power factor, load factor, voltage deviation, and harmonic limits should be incorporated into national grid codes. NEA and the Electricity Regulatory Commission must implement real-time monitoring, capacity planning, and phased grid reinforcement to ensure that EV load integration does not compromise grid stability or reliability.

#### **5.1.4 Standards and Specifications of Equipment/Products**

The technical performance and interoperability of EV chargers depend heavily on the quality and standardization of hardware and software components. Inconsistent product quality can lead to operational failures, safety incidents, and higher maintenance costs. Globally, standards such as IEC 61851 and BIS norms govern charger compatibility, plug types, communication protocols, and electrical performance.

This study concludes that Nepal must adopt and enforce mandatory equipment standards to ensure charger reliability, interoperability, and safety. Differentiating specifications for AC and DC chargers, encouraging modular system design, and certifying vendors will strengthen quality control. An official product certification and testing regime will help establish a trusted supply chain and ensure compatibility across brands and charging platforms.

#### **5.1.5 Identification of Optimum Number and Suitable Locations**

Optimal siting of EV charging stations is vital to ensure accessibility, high utilization, and economic viability. Nepal's diverse topography, traffic distribution, and infrastructure conditions require a data-driven approach to determine the appropriate number and placement of chargers. Tools such as GIS, and Multi-Criteria Decision Analysis (e.g., AHP) are essential for making informed planning decisions based on factors like grid proximity, land availability, and road gradient.

Nepal is actively promoting EV adoption to reduce air pollution, lessen dependence on imported fossil fuels, and fulfill its climate commitments. The government has established clear targets through national policies and climate pledges—including the NDC 3.0 and the net-zero emission strategy—aiming for rapid EV uptake across all vehicle segments by 2030 and 2045. While EV imports have grown strongly in recent years, challenges remain in developing the extensive charging infrastructure needed to support this shift. Therefore, strategic forecasting combined with optimal location planning is essential to ensure that the EV market and its supporting infrastructure evolve in a coordinated and sustainable manner.

The scenario analysis clearly shows that for Nepal to achieve its ambitious climate and electric vehicle targets, accelerated policy action and strategic infrastructure investment are crucial. While the Business as Usual path results in slow progress, aligning with the NDC commitments and especially the Net-Zero plan can drive significant growth in EV adoption and substantial reductions in CO<sub>2</sub> emissions. Success depends on combining detailed demand forecasting with careful spatial planning to deploy charging stations optimally—ensuring sufficient capacity and convenient access for users. The study highlights that systematic site selection, based on SNH 2020/21 traffic data and advanced spatial analytics, can enable an efficient and targeted infrastructure rollout. Priority should be given to locations along national highways, busy corridors, and areas with strong grid connectivity, while also accounting for environmental risks like flooding and slope instability. Conducting thorough field assessments and technical validations will further ensure practical feasibility, promoting balanced and inclusive deployment. This integrated approach is essential for sustainably scaling Nepal’s EV ecosystem, maximizing environmental and economic benefits, maintaining grid stability, and supporting the nation’s transition to clean energy.

### **5.1.6 Rollout Priority Plan for EV Public Charging Infrastructure**

Rolling out EV infrastructure simultaneously across all regions is neither financially nor logistically feasible. A phased rollout enables targeted deployment based on readiness, demand, and policy alignment. International experience shows that infrastructure is most effective when introduced first in urban and high-demand areas, followed by secondary and rural zones as adoption increases.

This study recommends a three-phase implementation plan for Nepal:

- **Phase I (1–3 years):** Highways and urban hubs with immediate demand
  - **Phase II (3–6 years):** Expansion to secondary routes and provincial centers
  - **Phase III (6-10 years):** Coverage in remote and underserved regions
- This structured rollout approach allows for resource optimization, lessons-learned feedback loops, and coordinated efforts across national, provincial, and local governments to support Nepal’s EV ecosystem.

### **5.1.7 Financial Analysis**

The deployment of public EV charging infrastructure entails high capital investment, long payback periods, and site-specific financial risks. In low-EV-density regions, financial viability may be uncertain without public support. Public-Private Partnerships (PPP), viability gap funding, and land leasing policies are commonly used around the world to share risks and attract private sector participation.

This study concludes that Nepal should adopt a PPP-based financial strategy with flexible models tailored to station categories and land ownership scenarios. Category-I (large) stations require higher investment but offer greater returns, while Category-II and III (small/medium)

stations may require public incentives or bundling to remain viable. Phased investment planning and targeted subsidies will be key to ensuring financial sustainability, encouraging private sector involvement, and scaling infrastructure across urban and rural areas.

## 5.2 ACTION PLAN & POLICY RECOMMENDATION

**Table 66: Action Plan**

Category	Policy/ Action Area	Key Actions	Responsible Organizations/Authorities
<b>Infrastructure Development</b>	Benchmarking Standards of Charging Stations	- Develop guidelines for optimal number and distribution of charging stations	Nepal Electricity Authority (NEA), Water and Energy Commission Secretariat (WECS), Alternative Energy Promotion Centre (AEPC), Academic Institutions
		- Review/adapt international standards for all vehicle types	
		- Legislate comprehensive EV & EVCS Act and Regulation	
	Establishment of EV Repair and Maintenance Centers	- Set up dedicated service centers in EV-dense areas	Ministry of Physical Infrastructure and Transport (MoPIT), Private Sector
		- Conduct training programs for mechanics/technicians	
		- Provide tools, diagnostics, and manuals	
<b>Fiscal and Financial Incentives</b>	Incentives to Promote EV Uptake	- Direct subsidies for EVs	Ministry of Finance (MoF) Electricity Tariffs Fixation commission Ministry of Finance (MoF), World Bank, ADB, UNDP, GEF, GCF, GGGI, Universities
		- Tax/custom duty reductions	
		- Reduced electricity tariffs for charging	
		- Facilitate modal shift to EVs	
		- Access international climate finance (World Bank, ADB, UNDP, GEF, GCF, GGGI)	
<b>Regulatory and Policy Framework</b>	Full Electrification of Government Fleets	- Mandate 100% EV adoption in public institutions	Ministry of Physical Infrastructure and Transport (MoPIT), All Government Ministries
		- Establish tracking/reporting systems as records of EV purchase and constructed EVCS.	
		- Monitor and review implementation progress of policies.	
	Develop EV Battery Recycling and Lifecycle	- Create national battery policy/framework to manage the entire lifecycle of EV batteries	Ministry of Physical Infrastructure and Transport (MoPIT), Private

Category	Policy/ Action Area	Key Actions	Responsible Organizations/Authorities
	Management guidelines	from production to disposal. - Establish enforcement/institutional infrastructure of EV Batteries regulations.	Sector, Academic Institutions
<b>Technology and Innovation</b>	Retrofitting Existing Vehicles to Electric Platforms	- Pilot retrofitting programs for buses/ trucks and others EV segments.	Ministry of Physical Infrastructure and Transport (MoPIT), Private Sector, Universities
		- Develop regulatory certification pathways	
	National Charging Infrastructure via PPP	- Implement PPP models for charging station rollout	NEA, Nepal Oil Corporation (NOC), Relevant Institutions, Private Sector
		- Foster NEA, NOC, and private sector partnerships	
<b>Public Awareness and Education</b>	Public Awareness and Education to promote e-mobility.	-Provide training sessions to understand new advancements in EV technologies, features, performance and innovations	NEA, WECS, / Alternative Energy Promotion Centre, Universities, Public Service Broadcasting Nepal
		-Cover details about different EV models, their specifications and the development of EVPCS for practical usage.	
		- Capacity building for local govts, businesses, civil society	

**Table 67: Policy Recommendation**

Policy Area	Recommended Actions	Key Barriers	Lead Responsibility	Supporting Authorities/ Stakeholders
<b>Dedicated Transportation Feeders for EV Charging Along National Highways</b>	- Develop exclusive feeders for EV charging along National highways	- High infrastructure costs	Nepal Electricity Authority (NEA)	Ministry of Energy, Water Resources and Irrigation (MoEWRD); Provincial Governments; Department of Roads; Local Municipalities
	- Coordinate with NEA for load forecasting and grid upgrades	- Limited grid capacity in rural/peri-urban areas		
	- Integrate smart grid and real-time monitoring	- Inter-agency coordination challenges		

Policy Area	Recommended Actions	Key Barriers	Lead Responsibility	Supporting Authorities/ Stakeholders
<b>NEA Tariff Rate for EV Charging</b>	<ul style="list-style-type: none"> <li>- Review and revise tariff structure to ensure cost recovery and fair returns for EVCS owner/operator.</li> <li>- Allow flexible margins for operators beyond fixed limits.</li> </ul>	<ul style="list-style-type: none"> <li>-Resistance to higher tariffs.</li> <li>- Regulatory delays.</li> <li>- Limited data on usage patterns.</li> </ul>	Electricity Tariff Fixation Commission (ETFC)	NEA, WECS, MoEWRI, Electricity Tariff fixation Commission, (ETFC), EVCS stakeholder
<b>Development of Human Resources in EV Sector</b>	- Strengthen CTEVT and launch EV-specific training to build a skilled workforce for EV service and repair.	- Shortage of qualified instructors	Council for Technical Education and Vocational Training (CTEVT)	Ministry of Education, Science and Technology (MoEST); Private Training Institutes; Automotive Industry Associations; Universities
	- Develop national EV curriculum	- Inadequate funding for training/labs		
	- Implement trainer-of-trainers and incentivize private certification	- Resistance from traditional technicians		
<b>Promotion of Public Electric Mobility to Reduce Congestion</b>	- Expand electric public transport (buses, light rail, trolleybuses) to reduce traffic congestion.	- High capital costs	Ministry of Physical Infrastructure and Transport (MoPIT)	Department of Transport Management (DoTM); Kathmandu Valley Development Authority (KVDA); Local Governments; Public Transport Operators
	- Incentivize operators to adopt e-buses	- Limited depot/grid readiness		
<b>Standardization of EV Charging Infrastructure</b>	- Formulate National EV Charging Standards (hardware, software, safety)	- Diverse stakeholder interests	Nepal Bureau of Standards and Metrology (NBSM)	NEA; Ministry of Industry, Commerce and Supplies (MoICS); EV Manufacturers/Importers; Technical Committees; Regulatory Authorities
	- Establish technical committees	- Technical expertise gaps		
	- Align with international standards (CCS2, CHAdeMO, GB/T)	- Multiple connector/voltage types		
	- Create a detailed electric mobility plan for Nepal, drawing inspiration from programs	- Multiple stakeholders (government, private sector, utilities) causing coordination delays		
	- Include subsidies for EV manufacturers, infrastructure development, and customer incentives to overcome sector challenges and encourage widespread EV use	- Lack of technical expertise in setting standards		
		- Varied EV models requiring different charging protocols		

Policy Area	Recommended Actions	Key Barriers	Lead Responsibility	Supporting Authorities/ Stakeholders
<b>EV Battery Management and Recycling</b>	- Enact National Battery Management Policy	- No existing recycling plants	Ministry of Forests and Environment (MoFE)	Ministry of Industry, Commerce and Supplies (MoICS); NEA; Local Governments; Private Recycling Firms; Importers/Dealers
	- Require recycling/ take-back plans	- High disposal/transport costs		
	- Promote PPPs for recycling facilities	- Low awareness on battery management		
	- Leverage international cooperation			
<b>Conversion of Fueling Stations into EV Charging Hubs</b>	- Encourage conversion/co-location at petrol stations	- High retrofitting costs	Ministry of Industry, Commerce and Supplies (MoICS)	Nepal Oil Corporation (NOC); NEA; Local Governments; Private Fuel Retailers; Department of Transport Management (DoTM)
	- Offer financial/regulatory incentives	- Resistance from fuel retailers		
	- Mandate EV infrastructure in new stations	- Unreliable electricity in remote areas		
<b>Balancing Fiscal Revenue Loss and National Savings</b>	- Develop compensation for lost fossil fuel tax revenue	- High dependency on petroleum tax	Ministry of Finance (MoF)	Ministry of Energy, Water Resources and Irrigation (MoEWRI); Department of Customs; Inland Revenue Department; National Planning Commission (NPC)
	- Implement road usage/electricity surcharges	- Lack of reliable usage data		
	- Use data to model long-term savings	- Public resistance to new taxes		
<b>Differential Electricity Tariffs for EV Charging</b>	- Introduce time-of-use (TOU) tariffs for off-peak charging	- Lack of advanced metering infrastructure	Nepal Electricity Authority (NEA)	Electricity Regulatory Commission (ERC); Ministry of Energy, Water Resources and Irrigation (MoEWRI); Local Governments
	- Deploy smart meters at charging stations	- Low consumer awareness		
	- Promote off-peak residential charging	- Risk of peak load imbalances		
<b>Financial Incentives for EV Adoption</b>	- Provide subsidies, zero-interest loans, tax/insurance rebates	- Budget constraints	Ministry of Finance (MoF)	Nepal Rastra Bank (NRB); Commercial Banks; Ministry of Physical Infrastructure and Transport (MoPIT); Local Governments
	- Encourage green financing via banks	- Credit risk perceptions		
	- Target schemes for low-income/small businesses	- Uncertainty in second-hand EV market		
<b>Scrappage Policy for ICE Vehicles</b>	- Implement phased scrappage for >15-year-old ICE vehicles	- Public unfamiliarity with scrappage	Ministry of Physical Infrastructure	Department of Transport Management

Policy Area	Recommended Actions	Key Barriers	Lead Responsibility	Supporting Authorities/ Stakeholders
	- Link scrappage with EV purchase incentives	- High cost gap between old ICE and new EVs	and Transport (MoPIT)	(DoTM); Ministry of Finance (MoF); Local Governments; Private Sector (Recycling/Disposal Firms)
	- Build vehicle recycling ecosystem	- Lack of recycling infrastructure		
<b>Establishment of EVPCI / EVCS</b>	- Develop the EVPCI / EV Charging Stations using a hub-based approach for optimal connectivity and scalability.	- Lack of standardized planning framework; limited technical capacity at local levels.	National Energy Authority (or relevant ministry)	Local municipalities, grid operators, private investors, transport authorities

### 5.3. MASTER PLAN REVISION STATEMENT

In recognition of the accelerating adoption of electric vehicles (EVs) in Nepal, the EV Charging Station (EVCS) Master Plan will undergo a comprehensive review and revision at a minimum interval of every five years. This structured, periodic reassessment is essential to ensure the Master Plan remains responsive to actual market developments, technological progress, and evolving policy imperatives.

#### Core Areas for Systematic Revision

- **Infrastructure Deployment Targets:** Updating the number, type, and locations of charging stations based on the latest EV market penetration and user demand trends.
- **Investment Requirements:** Reassessing total capital needs, cost structures, and funding mechanisms in line with real implementation experience and emerging opportunities.
- **Regulatory and Policy Frameworks:** Strengthening standards, operational guidelines, and incentives to facilitate greater private sector participation and address new challenges.
- **Grid Capacity and Technological Upgrades:** Reviewing distribution network requirements, smart grid integration, and new charging technologies to maintain service reliability.
- **Monitoring, Evaluation, and Governance:** Incorporating performance data and stakeholder feedback to enable adaptive management and continuous improvement.

By institutionalizing a regular revision cycle, the EVCS Master Plan will serve as a dynamic and adaptive roadmap, guiding Nepal's transition toward sustainable and inclusive electric mobility. This approach guarantees that the Master Plan remains aligned with the nation's evolving market realities, technological landscape, and policy priorities, thereby maximizing its effectiveness and long-term impact.

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