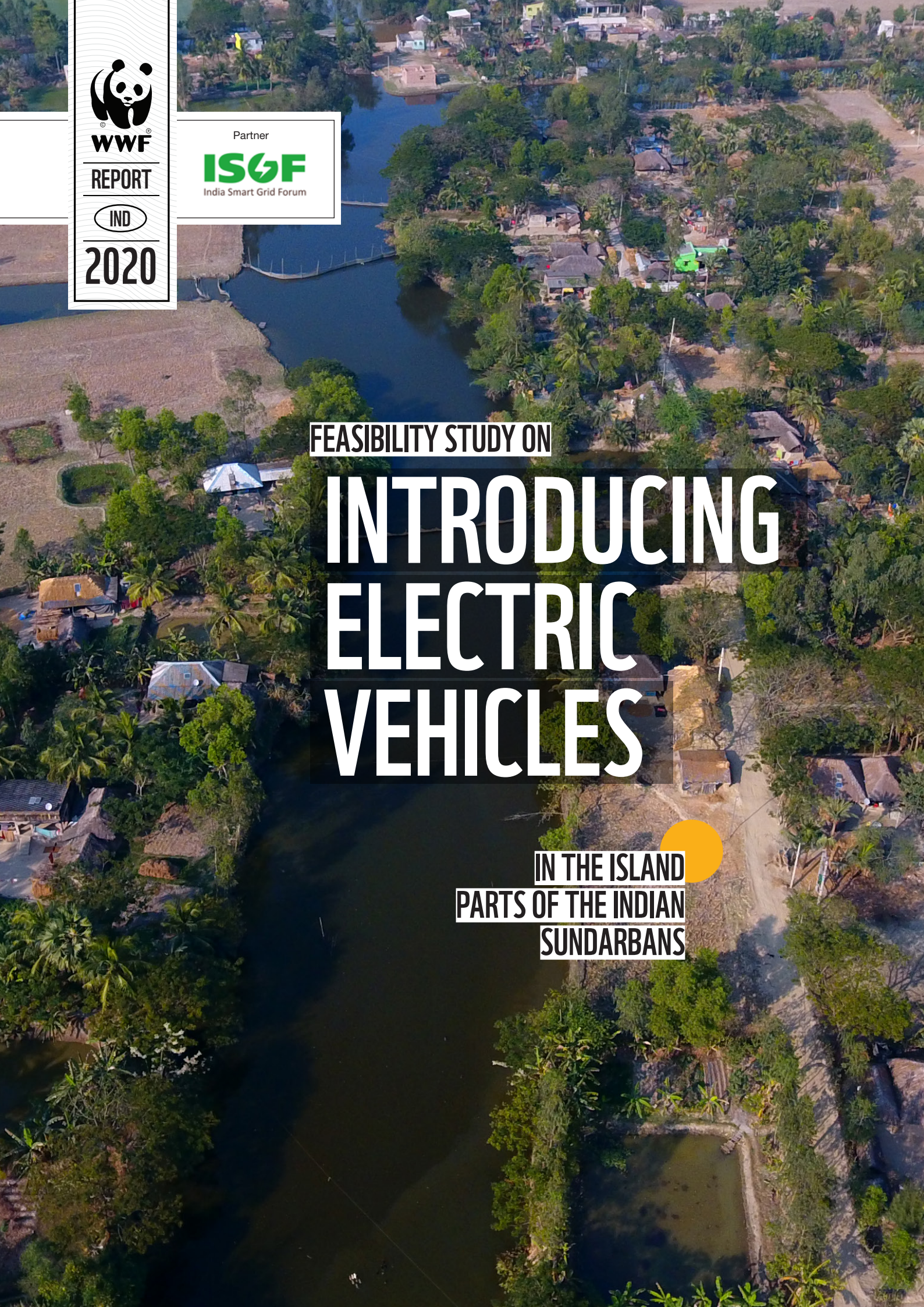

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REPORT

IND

2020

Partner

ISGF

India Smart Grid Forum

FEASIBILITY STUDY ON

INTRODUCING ELECTRIC VEHICLES

IN THE ISLAND PARTS OF THE INDIAN SUNDARBANS

Published by WWF-India & ISGF

Cover Image: Schneider Electric India Foundation

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Disclaimer

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FEASIBILITY STUDY ON

INTRODUCING ELECTRIC VEHICLES

IN THE ISLAND PARTS OF THE INDIAN SUNDARBANS

EXECUTIVE SUMMARY

INTRODUCTION

India, because of its unique geographical position, diverse terrain and climate, is rich in wetland ecosystems. The Sundarbans in India is one of its finest examples, and was accorded the status of 'Wetland of International Importance' under the Ramsar Convention. The Sundarbans can be considered the epitome of biodiversity, since it is home to many irreplaceable animals, bird and aquatic species; apart from being part of one of the largest mangroves in the world. This acts as a protective shield against the Bay of Bengal cyclones, effectively saving the lives of millions of people who live there.

Considering its ecological importance and environmental sensitivity, the government has focused on restoring this wetland, with efforts toward forest conservation, promotion of clean energy, development of roads, cent percent electrification, etc. However, the local transport system for last-mile connectivity in the Sundarbans remains a major concern. The connectivity to the islands from the main land and between the islands is limited. The primary mode of transportation on these islands are unsustainable, unsafe and unauthorised diesel-based engine vans and ferries. This has resulted in degradation of air quality, water pollution (through leakage of oil into water from boats) and health hazards for the local people, flora and fauna. According to a survey undertaken by WWF-India in 2011, existing passenger-carrying engine vans and ferries in the forest-fringe island parts of the Sundarbans results in GHG emission of approximately 8000 tonnes per year (4000 tonnes per year by engine-based tri-cycles and 4000 tonnes per year by ferries)[1].

Introduction of electric transportation could alleviate both transportation issues as well as pollution from emissions. With increasing household electrification and availability of mini-grid facilities based on renewable energy in most parts of the Sundarbans, deployment of electric vehicles and electric boats is now possible. This report examines the feasibility of replacing engine vans with e-rickshaws in parts of the Sundarbans as a pilot project.

OBJECTIVE AND APPROACH

WWF-India, in consultation with Department of Transport, Government of West Bengal, initiated a feasibility study and developed an action plan to promote electric

1 WWF-India internal report, 2011

mobility in the eight forest-fringe community development (CD) blocks in the Sundarbans region. It partnered with India Smart Grid Forum (ISGF) in January 2019 to conduct this feasibility study and prepare the action plan. However, as the scope of the project is limited to surface transport only, this report evaluates the feasibility of deploying e-rickshaws in eight CD blocks; namely Sandeshkhali, Patharpratima, Kultali, Basanti, Gosaba, Hingalganj, Namkhana and Sagar.

The report is structured into two parts. The first part focuses on the feasibility assessment of e-rickshaw deployment in the eight CD blocks mentioned above, taking into account policy and regulatory review, electrical infrastructure, financing options and institutional arrangement. The second part defines an action plan to facilitate the deployment of e-rickshaws; considering policy and regulatory requirements, incentive mechanisms, financing availability, electric grid upgradation, institutional changes, etc.

FEASIBILITY ASSESSMENT

With electric vehicles (EVs) becoming a priority, the central government has initiated various programs like National Mission on Electric Mobility, and Faster Adoption and Manufacturing of Electric Vehicles (FAME) to promote e-mobility in the country. Besides the introduction of EVs, EV manufacturing and the creation of a complete ecosystem for e-mobility and indigenisation of EV technology are the objectives of the national mission. After that, the state governments of various states like Karnataka, Maharashtra, Delhi, Andhra Pradesh, Telangana, Uttar Pradesh, and Kerala have also issued EV policies to support the central government's objectives, and to facilitate the adoption of EVs in their respective states. In the first section of this feasibility report, a review of the EV policies and schemes of different states has been carried out. The key features have been discussed, including the subsidy on various categories of EVs (electric buses, e-rickshaws, three-wheelers, taxi cars, two-wheelers, private vehicles), subsidy on EV charging stations, subsidised electricity tariff for EV charging; incentives like road tax exemption; a dedicated fund for research and development of EV technology; and special manufacturing zones for EVs. This review has been done in view of adopting the individual action points that are best suited to promote the usage of e-rickshaws in the Indian Sundarbans.

A similar assessment was also carried out on the EV-technology landscape to explore various types of EV-charging standards and communication protocols, battery and motor technologies. This will provide an understanding of the technologies and their requirements in various categories of EVs and enhance both their commercial viability and operational efficiency. For example, the usage of lithium-ion battery (LiB) instead of lead-acid battery in e-rickshaws will enhance the efficiency of the vehicle and significantly improve the return on investment (ROI) as the life of the LiB is 1500–3000 cycles, whereas that of lead-acid batteries are 300–500 cycles depending on the usage.

The second section of the feasibility assessment is a more focused review of the Sundarbans region, where ISGF engineers, along with WWF-India staff, have visited the eight CD blocks and conducted consultations with various stakeholders – owners and drivers of the engine vans operating in the identified routes, banks, rural cooperatives, gram panchayats and local employees of the electricity distribution

company – to assess the level of infrastructural (electrical), financial and institutional readiness to support the introduction of e-rickshaws in the region. The key findings of this assessment suggest the following:

1. There is no institutional mechanism or formal process defined to support the deployment of e-rickshaws. Administrative support has only been provided on a case-by-case basis.
2. Absence of type testing and certification by the government-authorised agencies and lack of regulatory guidelines have made the e-rickshaw segment a less attractive asset class for commercial banks to fund. However, various options are available from rural cooperatives and various government schemes, like Mudra Loan and Gatidhara scheme of the West Bengal Government, which offer easy and low-cost loans for the e-rickshaw segment. Prospective operators of e-rickshaws in the Sundarbans can easily avail these loans.
3. The electrical infrastructure has improved in the recent past; but round-the-clock power availability is still a concern owing to high losses and poor network reliability. Mini-grids powered by solar panels and DG sets are also being experimented with on a few islands. The electricity grid is expected to be made more reliable and capable of providing 24x7 power to all households soon. This would ensure the smooth charging of e-rickshaws.

Apart from the review of the above strategic elements, an implementation-level assessment has also been carried out in consultation with current and prospective owners and drivers of engine vans and e-rickshaws, respectively. We have also assessed the financial and environmental benefits that e-rickshaws with LiB have over engine vans in all the eight identified routes. Furthermore, we have assessed the commercial viability of the e-rickshaws with both LiB and lead-acid battery. The assessment scenarios suggest that:

1. In terms of battery technology, lithium-ion battery is far more commercially viable than its lead-acid counterpart owing to its longer life and better efficiency.
2. With the use of e-rickshaws, there can be a reduction of 6,88,389 kg per year of carbon dioxide emission in the eight routes that we surveyed.

ACTION PLAN

Based on the review and analysis carried out in the feasibility assessment section, an action plan has been charted out stating the key steps that need to be taken in terms of policy and regulatory requirements, incentive mechanism, financing modalities, institutional changes along with various business model options. This will facilitate successful deployment of e-rickshaws and implementation of supporting infrastructure in the Sundarbans region. Key points in the action plan are presented below:

1. Development of a Master Plan and Roadmap for deployment of e-rickshaws in the Sundarbans region
2. Regulatory regime for testing and certification of e-rickshaw registration to ensure proper institutional mechanism
3. Green business schemes by rural cooperatives to facilitate low-cost loans for e-rickshaws
4. Solar PV with battery banks to facilitate e-rickshaw charging
5. Subsidised tariff for e-rickshaw charging
6. Skill development and training for local people in e-rickshaw and related technology
7. Outreach and advocacy program, with support from the Department of Transport, Government of West Bengal, is required to generate awareness in grassroot level institutions like Gram Panchayat, Panchayat Samiti, Zilla Parishad
8. Consultations with local leaders of unions of engine-van operators in order to make them aware of the technology, operating procedure and benefits of e-rickshaws in terms of commercial, social and environment benefits and also to understand their views on the implementation of e-rickshaws on their respective islands

WAY FORWARD

Considering the socio-economic and environmental benefits from the replacement of engine vans with e-rickshaws in the Sundarbans, a focused program may be launched. As a next step, electrification of the diesel boats must be taken up, which are an important means of last-mile connectivity and a major source of both air and water pollution. These programs will certainly enhance the sustainability for the transportation sector and ensure better living conditions for the people residing in the Sundarbans.

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ACRONYMS AND ABBREVIATIONS

2W	Two-Wheeler
3W	Three-Wheeler
4W	Four-Wheeler
AC	Alternating Current
APL	Above Poverty Line
ARAI	Automotive Research Association of India
BEST	Brihanmumbai Electric Supply & Transport Undertaking
BIS	Bureau of Indian Standards
BLDC Motor	Brushless DC Motor
BMS	Battery Management System
BMTC	Bengaluru Metropolitan Transport Corporation
BPL	Below Poverty Line
CAPEX	Capital Expenditure
C Rate	Charge Rate
CAN	Control Area Network
CCS	Combined Charging System
CD BLOCK	Community Development Block
CHAdeMO	Charge de Move
CMS	Central Management System
CSR	Corporate Social Responsibility
DC	Direct Current
DCFC	Direct Current Fast Chargers
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DHI	Department of Heavy Industries
DT	Distribution Transformer
EESL	Energy Efficiency Services Limited
EOI	Expression of Interest
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
EVSP	Electric Vehicle Service Provider
FAME	Faster Adoption & Manufacturing of Electric Vehicles
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GOI	Government of India
HT	High Tension

HV	High Voltage
ICAT	International Centre for Automotive Technology
IM	Induction Motor
INR	Indian Rupee
IPDS	Integrated Power Development Scheme
ISGF	India Smart Grid Forum
KM	Kilo Meter
KV	Kilo Volt
KVA	Kilo Volt Ampere
KW	Kilo Watt
KWH	Kilo Watt Hour
KWP	Kilo Watt Peak
LFP	Lithium Iron Phosphate
LMV	Low and Medium Voltage
LT	Low Tension
LTO	Lithium Ion Titanate Oxide
LTR	Litre
LV	Low Voltage
OEM	Original Equipment Manufacturer
OPEX	Operating Expenditure
MOSFET	Metal Oxide Semiconductors Field Effect Transistors
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MSME	Micro, Small and Medium Enterprises
MVA	Mega Volt Ampere
NCA	Lithium Ion-Nickel Cobalt Aluminium
NCR	National Capital Region
NDC	National Determined Contributions
NMC	Lithium Ion - Nickel Manganese Cobalt
NSCFDC	National Scheduled Castes Finance and Development Corporation
OBC	Other Backward Class
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer
PPAC	Petroleum Planning and Analysis Cell
PM	Permanent Magnet
PMMY	Pradhan Mantri Mudra Yojna
PNB	Punjab National Bank
PSU	Public Sector Undertaking
R&D	Research and Development
RPM	Revolutions per minute
RTO	Regional Transport Office
SAUBHAGYA	Pradhan Mantri Sahaj Bijli Har Ghar Yojana

SC	Scheduled Caste
SCA	State Channelizing Agency
SERC	State Electricity Regulatory Commission
SGST	State Goods and Service Tax
SHG	Self Help Group
SIAM	Society of Indian Automobile Manufacturers
SKUS	Samabay Krishi Unnayan Samiti
SOP	Standards of Performance
SRM	Switched Reluctance Motor
ST	Scheduled Tribe
TOD	Time of Day
UI	User Interface
UNDP	United Nations Development Programme
USD	United States Dollar
WBREDA	West Bengal Renewable Energy Development Agency
WBSEDCL	West Bengal State Electricity Distribution Company Limited
WBTC	West Bengal Transport Corporation
WWF	World Wide Fund For Nature

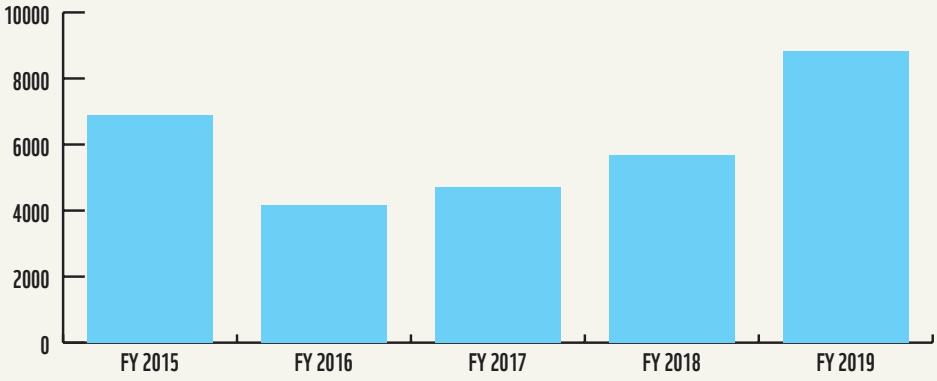
1. INTRODUCTION

According to a study conducted by Petroleum Planning and Analysis Cell (PPAC) of Petroleum Ministry in 2014,

70%
OF DIESEL AND
99.6%
PETROL IS CONSUMED IN THE TRANSPORT SECTOR ALONE.

The concern for increase in greenhouse gases and need for a low-carbon economy has been acknowledged by several countries and led to the adoption of the Paris Agreement in December 2015. This envisages the limitation of global temperature rise well below two degrees Celsius above pre-industrial levels by 2100 and to pursue efforts to limit the increase to 1.5 °C. India, as a party to the Paris Agreement, has shown its commitment to combat climate change and has taken actions that are indeed important contributions to the global effort. Decarbonisation action plans need to be adopted to address greenhouse gas (GHG) emissions and drive new economic opportunities, while improving the quality of life of the citizens. Amongst others, these plans should address key sectors, such as power and transport. These sectors will be responsible for significant increase in carbon emissions in the coming years, primarily driven by accelerated urbanization and economic growth.

FIGURE-1: India - Crude oil import bill (in billion INR)



India, on the verge of transition from a developing to a developed economy, has been experiencing a GDP growth of 6.7% in 2017-18 and is expected to grow in the next five years. This will subsequently lead to an increase in consumption of crude oil and oil products in terms of primary energy consumption. According to the Indian Brand Equity Foundation the demand is expected to increase by three times to approximately 1,516 million tonnes of oil by 2035. Moreover, there has been a considerable increase, that of 31%, in the crude oil import bill for fiscal year 2018-19, as compared to fiscal year 2017-18. With the transport sector being one of the highest contributors to oil consumption (47%), increased use along with import dependency will not only increase GHG emission (11% from transport sector) but will also have substantial impact on the energy security scenario of the country. Therefore, to address these issues, the transportation sector needs to undergo a significant transformation; from an oil-based system to a more environment-friendly electricity-based system. India, has acknowledged the contribution of transport sector to the problem and therefore, included the adoption of the Electric Vehicles as a prioritized action item. Moreover, with electricity peak deficit being reduced to 0.8% and India's target of 160 GW renewable energy (solar and wind) by 2022, given that we can integrate the electric

INDIA RANKS **NO. 3** IN TERMS OF GLOBAL OIL CONSUMPTION

↑**20%** INCREASE IN OIL IMPORT IN THE LAST FIVE YEARS

↑**36%** INCREASE IN FUEL PRICE FROM FY 2014 -FY 2018

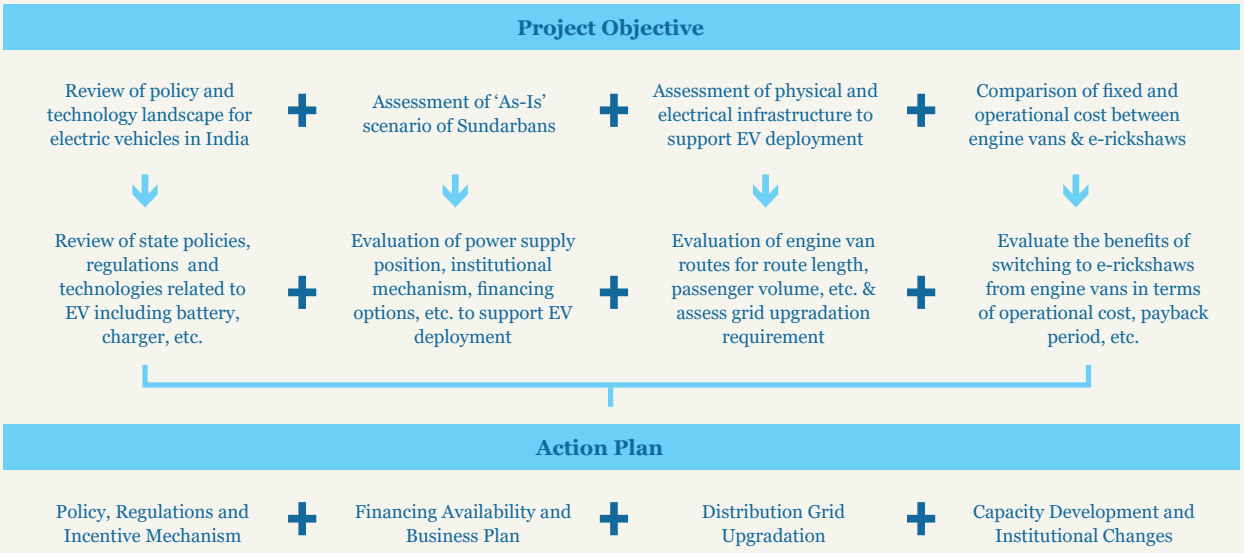
INDIA RANKS 177 OUT OF 180 COUNTRIES IN ENVIRONMENTAL PERFORMANCE INDEX 2018

mobility plan with the power sector development plan; one can confidently assert that implementation of a cleaner transport solution is imminent.

1.1 PROJECT OBJECTIVE AND OUTCOME

The Indian Sundarbans, an eco-region of global importance, is a cluster of islands in the Bay of Bengal, separated from one another and the mainland by interconnected rivers, creeks and canals. This makes last-mile connectivity in the region extremely challenging. The current transportation options used in the Sundarbans are mainly engine vans which are polluting and also prone to accidents as they are manufactured locally without any standard guidelines. Therefore, introduction and scaling up of electric mobility in the region, mainly in the form of electric vehicles, will lead to cleaner and more sustainable forms of transport systems. This will also have a positive impact on the livelihoods and environment in the Sundarbans region.

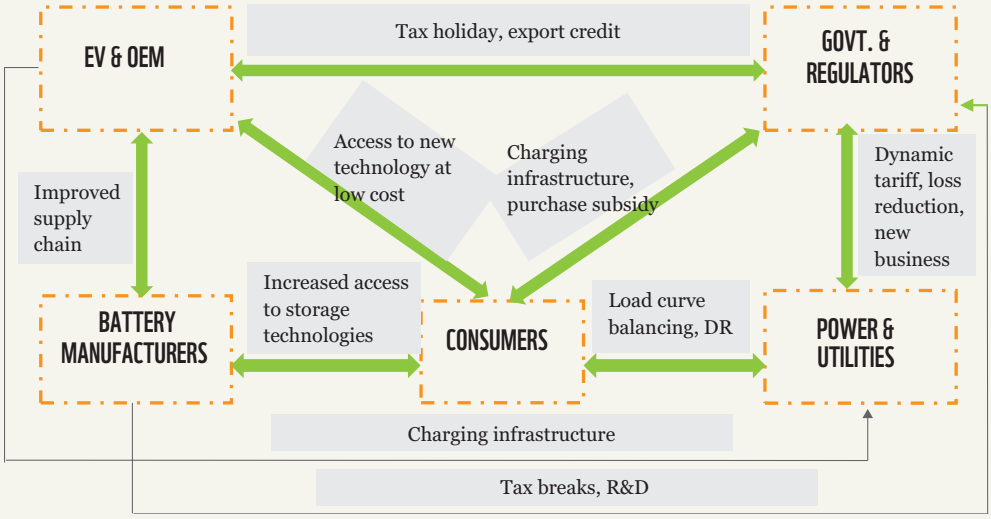
Considering this, WWF-India, along with its technical partner India Smart Grid Forum, undertook this study, which aims to develop an action plan for the introduction and scaling up of electric vehicles in the eight forest fringe CD blocks in the Sundarbans region.



1.2 ELECTRIC VEHICLES (EV)

Electric Vehicles (EVs) and services represent new economic pathways to increase energy security (avoid oil imports), reduce carbon emissions (ensure sustainability) and improve air quality (better human health). However, it presents a complex economic interaction across the energy, manufacturing, consumer and government sectors as depicted below:

FIGURE-2 Electric Vehicle Ecosystem



1.2.1 POLICY LANDSCAPE

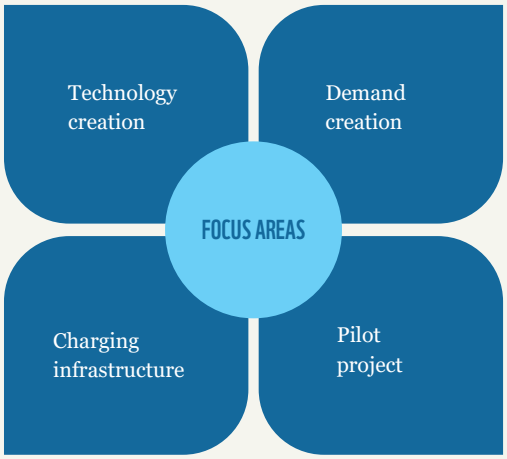
Considering the above issues and in order to address each and every aspect of the value chain, the Government of India has come out with various initiatives to accelerate the deployment of electric vehicles in the country.

National Mission on Electric Mobility

In 2013, the Government of India came out with the National Mission on Electric Mobility, which aimed to bring about transformational change in the automotive space along with a certain level of indigenisation of technology to ensure India's global presence in the EV segment. Under this, GoI in 2013 devised the National Electric Mobility Mission Plan 2020 which planned on the introduction of about 6-7 million electric/hybrid vehicles in India by the year 2020 with 4-5 million Two-Wheeler (2W) EVs and 1-2 million Four-Wheeler (4W) EVs. This plan required an investment of 23,000 crores (approx. 3 billion USD). It also underlines the importance of government incentives and coordination between industry and academia to work on research and development for technology enhancement, along with the need to increase efficacy of the EV deployment model. In 2018, the Government of India has also come up with the National Electric Mobility Program which ensures 30% electric vehicles on the road by 2030[2].

2 Ministry of Power, Government of India (http://pib.nic.in/newsite/PrintRelease.aspx?relid=177134)

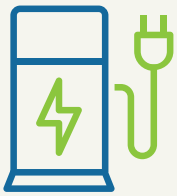
Faster Adoption & Manufacturing of Electric Vehicles (FAME)



The FAME India scheme was launched in 2015, with the objective to support the hybrid/electric vehicles market development and manufacturing eco-system. The phase I of the scheme is being implemented for a period of 2 years, i.e. FY 2015-16 and FY 2016-17 commencing from 1st April, 2015. In support, the GOI has allocated INR 1,000 crores or USD 150 million for FY 2016 & FY 2017. The scheme is aimed at incentivising all vehicle segments, i.e., 2 & 3 wheelers, 4 wheelers, Light Commercial Vehicles and buses and also covers hybrid and electric technologies like Mild Hybrid, Strong Hybrid, Plug-in Hybrid and Battery-Electric Vehicles.

Under this scheme, about 99000 hybrid/electric vehicles (EVs) have been given direct support till 2017 by way of demand incentives since the launch on 1st April, 2015. In FY 2015-16, passenger cars contributed 81.3% of the total demand incentive utilization, with two-wheelers constituting the remaining 18.7%. Among passenger cars, 73% of the funds were utilized by mild hybrid cars, 11% by strong hybrid cars, and 16% by battery-operated electric cars. All the two-wheelers registered under the scheme are battery-operated electric models and no eligible models were registered under the scheme across other vehicle segments. Since the inception of FAME I, 2,78,701 electric and hybrid vehicles were sold, which helped in the reduction of both fuel consumption as well as GHG emission.

APPROX. 4.5 CRORES LITRES OF FUEL SAVED + **APPROX 11 CRORE KG OF CO_2 REDUCTION**



IT IS EXPECTED THAT 30,000 SLOW CHARGING AND 15,000 FAST CHARGING STATIONS WILL BE REQUIRED TO BE PUT UP IN PHASE MANNER IN NEXT 3 TO 5 YEARS

TABLE-1: Electric Vehicles sanctioned by DHI

Sl. No.	Cities	Electric buses	e-Taxis	Three wheelers
1	Kolkata	80	200	--
2	Ahmedabad	40	20	20
3	Bengaluru	40	100	500
4	Jaipur	40	--	--
5	Mumbai	40	--	--
6	Lucknow	40	--	--
7	Hyderabad	40	--	--
8	Indore	40	50	200
9	Jammu	15	--	--
10	Guwahati	15	--	--

Source: DHI

Apart from that, in October 2017, the Department of Heavy Industries (DHI) invited Expression of Interest (EoI) from all cities for funding of electric buses, taxi fleets and three wheelers. 27 cities participated in the EoI stage, out of which 10 cities have been allocated funds for the procurement of aforementioned vehicles. Under this scheme, the government has sanctioned a total of 390 buses, 370 taxis and 720 three-wheelers and will allocate a total outlay of INR 5.37 billion. DHI has also approved funding for an additional 130 electric buses which includes 50 buses to Ahmedabad, 50 buses to Himachal Pradesh and 30 buses to Navi Mumbai[3]. DHI also circulated a proposal suggesting that at least one charging point be planned every 9 square kms in all metros, million-population-plus cities and identified smart cities; while a charging station on both sides of the highway be planned every 25 kms along the Delhi-Jaipur, Delhi-Chandigarh, Chennai-Bengaluru and Mumbai-Pune stretches.

In March 2019, the Government of India also came out with the second phase of the FAME scheme with a total out lay of INR 100,000 million, which will cover the purchase of one million electric 2W, half a million electric 3W, 55,000 electric 4Ws and 7,000 electric buses. The subsidy under this scheme will only be applicable for commercial vehicles and public transport along with two-wheelers and will be implemented for a period of three years, starting from 2019 to 2022. It will also offer exemption from road tax and registration charges for electric vehicles. Moreover, an inter-ministerial empowered committee, the Project Implementation and Sanctioning Committee, will be formed to sanction assistance for projects under the scheme and modify its various components based on the requirement.

TABLE-2: Fund requirement under FAME Scheme

Sl. No.	Component	2019-20	2020-21	2021-22	Total fund requirement (in crores INR)
1	Demand Incentives	822	4587	3187	8596
2	Charging Infrastructure	300	400	300	1000
3	Administrative expenditures	12	13	13	38
Total for FAME II		1134	5000	3500	9634
4	Committed expenditure of Phase I	366	0	0	366
Total		1500	5000	3500	10000

Source: ISGF

At a national level, Energy Efficiency Services Limited (EESL) has also been given the mandate for the deployment of Electric Vehicles on a pan-India basis. The mandate has been given to EESL under the National Electric Mobility Mission Plan and will avail all the benefits proposed under the FAME scheme. Previously, EESL has tendered out 10,000 EVs, and 125 charging stations (100 AC & 25 DC charger) in Delhi/NCR, which have already been deployed in various government buildings. In Andhra Pradesh, EESL has proposed to supply 10,000 electric vehicles and 4000 charging stations to various government departments.

3 https://india.uitp.org/news/dhi-extended-fame-scheme-march-2019

At the state level, various state governments like Karnataka, Maharashtra, Uttar Pradesh, Andhra Pradesh, Kerala, Telangana, and Delhi have come out with their respective state policies (both draft and final) focusing on manufacture and deployment of electric vehicles in their states.

Some of the key aspects of a few state policies offer various benefits, as listed below:

KARNATAKA

- Exemption of road taxes for all electric non-transport and transport vehicles
- Exemption of stamp duty and concessional registration charges
- 100% exemption of duty/tax on electricity tariff
- Capital subsidy of 25% on charging equipment (max INR 500,000 per station for first 50 stations)
- Skill Development Center for training on EV
- Investment promotion subsidy for EV manufacturers (20-25%)

MAHARASHTRA

- Target manufacturing of 5 lakhs EVs in the state
- Electrical power for EV charging @ INR 6.00/unit
- 10% subsidy on passenger buses, max 20 lakhs (2 million) per vehicle
- Exemption from road tax & registration fees
- Capital subsidy of 25% on charging equipment (max INR 1 million per station for first 250 commercial charging station)
- 15% subsidy on first 1 lakh EVs
- Refund of SGST if electric car sold within state

TELANGANA

- 100% transition to electric mobility by 2030
- Road tax exemption for all electric vehicles till 2025,
- Encourage cab operators/ aggregators to switch to full EV fleet
- Free Parking in public parking places and toll exemption on State Highways till 2025
- Corporate offices to move to EV for staff movement
- Exemption of registration charge
- Automotive park for EV manufacturing
- Technology cluster for R&D on EV technology

UTTAR PRADESH

- 100% exemption of road tax on EVs purchased within Uttar Pradesh
- 30% subsidy on road price of EV (families with single-girl child)
- Capital Interest Subsidy of 5% per annum for 5 years (max INR 1 million per year) for charging stations with investment between INR 2.5 million and INR 50 million
- Exemption of electricity duty for 10 years for EV manufacturers
- Skill development-20% paid by govt.

In addition to EV-specific policies, State Electricity Regulatory Commissions (SERCs) have issued separate tariffs for electric-vehicle charging, which is listed below:

TABLE-3: Electricity Tariff for Electric-Vehicle Charging in India

	State	Category	Tariff		
			Energy Charge	Fixed Charge	TOD/Surcharge/Rebate
1	***Delhi (Tariff Order 16.3.2018)***	Separate Category	Supply at LT – Rs. 5.50/kWh Supply at HT – Rs. 5.00/kWh	No fixed charge	May-September Peak Hours: 1400 Hrs – 1700 Hrs & 2200 Hrs – 0100 Hrs Surcharge-20% Off Peak Hours: 0400 Hrs – 1000 Hrs Rebate-20%
2	***Punjab (Tariff Order 19.4.2018)***	Commercial	Rs. 5.00/kWh	No fixed charge	-
3	***Maharashtra (Tariff Order 12.9.2018)***	Separate category at LT and HT level	Rs. 6.00/kWh	Rs. 70/kVA/ Month	-
4	***Jharkhand (Tariff Order 28.2.2019)***	Commercial	Rural – Rs. 6/kWh Urban - Rs. 6.25/ kWh	Rural - Rs. 40/ Conn/Month Urban – Rs. 150/ Conn/Month	-
5	***Andhra Pradesh (Tariff Order 22.2.2019)***	LT: II (C) Non-domestic HT Category-II(E): Electric Vehicles (EVs) / Charging Stations	Rs. 5/kWh	-	-
6	***Haryana (Tariff Order 1.11.2018)***	LT	Rs. 6.50/kWh	Rs. 160/kVA/ Month	-
		HT	Rs. 6.40/kWh		
7	***Karnataka (Tariff Order 14.5.2018)***	LT and HT	Rs. 4.85/kWh	LT – Rs. 50/kW/ Month HT – Rs. 180/ kVA/Month	-
8	***Uttar Pradesh (Tariff Order 25.2.2019)***	LMV-1b & HV-1b LT and HT (metered consumers of LMV-1, LMV-2(a), LMV2(c), LMV-4, LMV-6, LMV-7, LMV-8 (Metered), LMV-9 (Metered), HV-1, HV-2, HV-3 and HV-4 to be charged as per respective category tariff)	LMV-1b - Rs. 6.20 / kWh HV-1b - Rs. 5.90 / kWh LT - Rs. 7.70 / kWh HT - Rs. 7.30 / kWh	No fixed charge	Summer Months (April to September): 05:00 hrs – 11:00 hrs: -15% 17:00 hrs – 23:00 hrs: +15% Winter Months (October to March): 17:00 hrs – 23:00 hrs: +15% 23:00 hrs – 05:00 hrs: -15%
9	***Gujarat (Tariff Order 3.3.2018)***	LT and HT	LT – Rs. 4.1/kWh HT – Rs. 4/kWh	LT - Rs. 25 per installation HT - For billing demand up to contract demand Rs. 25/- per kVA per Month HT - For billing demand in excess of contract demand Rs. 50/- per kVA per Month	-

	State	Category	Tariff		
			Energy Charge	Fixed Charge	TOD/Surcharge/Rebate
10	Telangana (Tariff Order 15.11.2018)	LT and HT	LT – Rs. 6/kWh HT – Rs. 6 + TOD Charges	No fixed charge	6 AM to 10 AM and 6 PM to 10 PM: Rs. +1/kWh 10 PM to 6 AM: Rs -1/kWh
11	Chhattisgarh (Tariff Order 28.2.2019)	LV-2.1: Non-Domestic LV-2.2: Non-Domestic Demand Based Tariff (for Contract Demand of 15 to 112.5 kW) Supply Voltage HV- 3	Rs. 5/kWh	No fixed charge	-
12	Madhya Pradesh (Tariff Order 3.5.2018)	LV – 5 and HV – 4: Electric Vehicle/ Rickshaw charging installations	Rs. 4.08/kWh	No fixed charge	-

Source: State EV policies and electricity utility tariff regulations of different states

Apart from policy initiatives, various states like West Bengal, Telangana, Himachal Pradesh and Karnataka have also started deployment of EVs on pilot basis.

Himachal Pradesh

The Himachal Pradesh State Transport Corporation has introduced 11 electric buses in August 2017 in tourist areas. These are 9-metre-long air-conditioned buses with a seating capacity of 35 and driving range of 200km. The buses and charging stations were supplied by Goldstone, Hyderabad, an associate of BYD, China.

Maharashtra

BEST, Mumbai has introduced four electric buses in Sept 2017 in Mumbai. These are non-AC buses (9 meters in length) with a seating capacity of 35 and driving range of 200km. The buses and charging stations were supplied by Goldstone, Hyderabad, an associate of BYD, China. Cab aggregator OLA has introduced 100 e-taxis and four charging stations to facilitate these e-taxis in Nagpur. 500 charging stations will also be deployed by Maharashtra State Electricity Distribution Company Limited (MSEDCL) across Maharashtra by 2020 in a phased manner. In the first phase of the project, 50 such stations will come up with Mumbai, Navi Mumbai and Panvel having four charging stations each, six charging stations for Thane, 10 charging stations each for Pune and Nagpur and 12 charging stations for Mumbai-Pune Expressway. Moreover, the tariff for charging has been fixed at INR 6/kWh and INR 70/kVA per month.

West Bengal

The West Bengal Transport Corporation (WBTC) has been allotted a grant by DHI for 80 buses and 200 EV taxis under the FAME scheme. The state government has also approved a budget for 20 electric buses during FY 2018. As mentioned above, WBTC has awarded the contract for both bus and charging station to Tata Motors Pvt. Ltd. and has allocated nine depots and nine terminuses to support operation of these 80

electric buses in 10 identified routes. Out of these 80 buses (40 nos. of nine-meter buses and 40 nos. of 12-meter buses), 20 buses have already started operations from three depots and a total of 32 charging stations have been installed in four depots and three terminuses. In addition, Housing and Infrastructure Development Corporation has also introduced six electric buses and three charging stations in New Town Kolkata, while New Town Kolkata Development Authority has recently introduced 10 electric vehicle charging stations (both slow and fast charging stations) at strategic locations in New Town to encourage the adoption of electric vehicles.

Karnataka

Bengaluru Metropolitan Transport Corporation (BMTC) had already floated tenders for procurement of 150 electric buses. BMTC has also been awarded a grant for 40 buses under the FAME scheme. In addition, 100 e-taxis and 500 e-rickshaws are also being provided grants under this scheme. The 2019 budget for the Karnataka government has also proposed EV-charging stations across 10 metro stations in the city, as part of the state government's comprehensive mobility scheme.

Delhi

The Delhi government has approved a proposal to introduce 1,000 low-floor AC electric buses to the national capital's public transport fleet and has come out with a tender to procure 385 electric buses under two clusters – E1 and E2. E1 shall have a requirement of 275 buses and cluster E2, 110 buses.

Telangana

Out of 40 electric buses allocated to Hyderabad by DHI, all buses have completed their trial run and 20 buses each have been allocated to Miyapur depot and Cantonment depot. These 12-meter, air-conditioned Olectra-BYD buses, with seating capacity of 40, will be plying mainly from different locations of the city, to Hyderabad International Airport. To support the operation of these buses, charging stations have been implemented in depots for both overnight and opportunity charging.

Some of the other policy initiatives in the country include:

- Green number plates for electric vehicles
- Provision of 20% parking space for electric vehicles with charging points in all new commercial buildings in the country
- EV charging standards (IS 17017 Part-1) issued in August 2018; accompanying standards are under finalization
- Model concession agreements for public private partnership for operation and maintenance of electric buses

Charging standards
CCS, CHAdeMO, Bharat Specific Charger for DC charger & Bharat charger for AC charging

Space for charging stations in buildings
20% parking space for charging stations in buildings

Concession agreement for PPP in O&M for electric buses
Private operator to procure and maintain buses as well as the depots against a specified fee/km

In this strive towards e- mobility, the e-rickshaw segment has gained maximum momentum, with more than 2 million e-rickshaws currently running across the country. Although this segment is not regulated, its ability to penetrate due to its low capital and operating cost has established these e-rickshaws as the most preferred option of first- and last-mile connectivity in many rural, peri-urban and urban areas. Apart from this, its easy accessibility to commuters and its use as a para transit mode in cities made it also an integral part of urban mobility. ***According to a report by AT Kearney, as many as 11,000 new e-rickshaws are on the roads every month and sales of e-rickshaws are set to go up by 9% every year by 2021.***

However, adoption and implementation of electric vehicles on a large scale will also require availability of technology and efficient implementation along with policy support, financial incentives, institutional strengthening, etc. The section below describes various technologies available for battery, charging station, motors along with their technical standards.

1.3 TECHNOLOGY

The key technology ingredients of an electric mobility system comprise the battery, battery management system (BMS), motor, charging stations and their interface standards for operation and communication, the details of which are described below.

1.3.1 BATTERY

Batteries are the most important component in an EV and constitute approximately 50-60% of the cost of the EV. The battery in an EV should be robust enough to handle high power, should have high energy capacity, should be stable and ideally, be lightweight in order to reduce the deadweight in the vehicle, which impacts energy efficiency. There are different types of battery chemistry, which varies based on the composition, performance, durability and charge capacity. For e.g., high charge rate can charge the battery in less time, higher energy density suggests long range, etc. Various parameters for different types of batteries are mentioned below:

TABLE-4: Battery Parameters

Battery Chemistry	Maximum charge rate (C); 1C refers to full charge in one hour	Maximum Temperature (Degree C)	Life (Maximum Cycles)	Energy Density (Wh/kg for cell)	Average Module Price (US$/kWh in 2018)
Lithium Ion Iron-Phosphate (LFP)	Up to 2C	40	1500-3000	100-130 Wh/kg	270
Lithium Ion- Nickel Manganese Cobalt (NMC)	C/2	40	1000-2000	230-250 Wh/kg	250
Lithium Ion- Nickel Manganese Cobalt (NMC)	3C	40	3000-4000	200Wh/kg (for NMC 811)	400
Lithium Ion- Nickel Cobalt Aluminium (NCA)	2C	40	1000-1500	250-270 Wh/kg	230
Lithium Ion Titanate Oxide (LTO)	6C	60	7500-10000	50-80Wh/kg	700

Source: ISGF

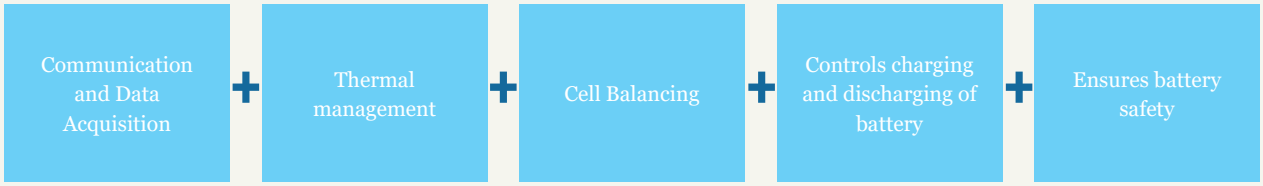
Currently all the electric vehicles are running on lithium ion Iron-Phosphate batteries due to their low cost as compared to others and decent charging rate of 2C. However, e-rickshaws are still operating on lead-acid battery, which costs around INR 28,000 to INR 38,000 depending on its capacity.

TABLE-5: Battery Specifications for e-rickshaws

Battery Specifications for e-rickshaws	
Nominal Voltage	48 volts (4 lead acid batteries)
Battery Capacity	3.8 to 5.7kWh
Battery Life	6-12 months
Charging Time	8-10 hours
Battery Price	INR 7000-8000 per battery
Driving Range per Charge	70-100kms

Source: ISGF

Moreover, the performance of these batteries also depends on current, voltage and charge requirement of the battery cells, which is being internally monitored through a battery-management system. The BMS is fully integrated with the battery chemistry and its thermal properties and determines the charging rate depending on the input voltage, current, ambient temperature and the state of charge of the battery. When an EV is connected to an EV charger, a hand-shake is established between the EV and the charger and the BMS in the EV takes control over the charging process. Various functions of BMS are given below:

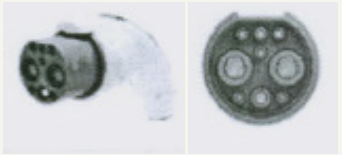


1.3.2 ELECTRIC VEHICLE SUPPLY EQUIPMENT

Charging infrastructure will play an important role on EV deployment, and improper planning and implementation of charging infrastructure can be a major impediment to mass market adoption. The charging infrastructure mainly referred to as EVSE, helps in charging the electric vehicle from the electricity grid.

The EVSE or charging equipment can be broadly classified as AC charging and DC charging devices. The battery in the EV require direct current (DC), which a DC charger can supply directly to the EV battery. Alternatively, an AC-DC converter on-board the EV can convert the AC supply from the AC charger and supply DC to the EV battery. For AC charging, the vehicle should have an AC-DC converter on-board, which would, on the down side, add to the cost and weight of the EV. However, almost all EVs have a small AC-DC converter, so that the EV can be charged from any AC supply. DC Fast Chargers (DCFC), on the other hand, with high power output can supply DC power to the battery and can charge the EV battery much faster. A 50kW DCFC can charge an EV with a 25kWh battery in 30 minutes (theoretically). DCFCs are more economical as the AC-DC conversion takes place in the EVSE itself rather than inside the vehicle. There are different types of AC and DC Chargers with different communication protocols which are described in the table below:

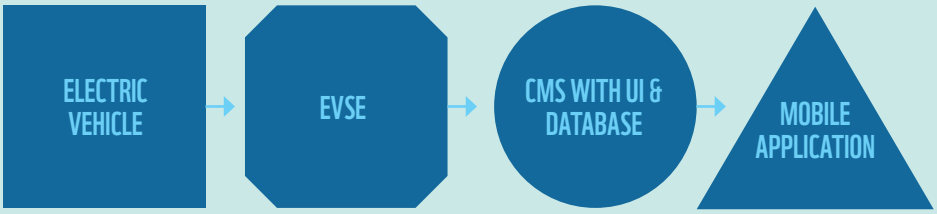
TABLE-6: Different types of AC and DC Chargers for electric vehicles

Charger Types & Sockets	Picture	Origin and Popular EV Models	Maximum Power Output and Communication Protocols
A. AC Chargers			
Type-1 with Yazaki Socket		Japan, USA (uses separate standard – JSAE 1772 due to 110 Voltage)	Up to 7.4kW (32 Amps, Single Phase)
Type-2 with Mennekes Socket		Manual 3 phase AC at high power—SAE J-3068	Up to 44kW (63 Amps, 3 Phase)
Type-3 with Le Grand Socket		France and Italy – some European cars	Up to 22kW (32 Amps, 3 Phase)
B. DC Charger Types			
CHAdeMO		Origin from Japan; Most popular DC charger in the world; used in Japan, Korea and parts of USA and Europe; Nissan Leaf, Mitsubishi, Kia, etc	Up to 400kW DC charging (1000 Volts, 400 Amps); Control Area Network (CAN) for communication between EV and EVSE
GB/T		Used in China; as well as Bharat Chargers in India; Chinese Vehicles and Mahindra Electric in India	Up to 237.5kW DC charging (950 Volts x 250 Amps); CAN for communication between EV and EVSE
Tesla Super Charger		Tesla has its own supercharger. Tesla also sells an adapter for connecting to a CHAdeMO charger	Up to 135kW DC charging (410 Volt x 330 Amp); CAN for communication between EV and EVSE
C. Combined (AC and DC) Chargers			
SAE Combined Charging System (CCS)		CCS-1 and CCS-2 versions available; same plug used for both AC and DC charging; Most European Cars - Audi, BMW, Daimler, Ford, GM, Porsche, VW, etc	Up to 43kW AC and up to 400kW DC (1000 Volt x 400 Amp) Power Line Communication (PLC) for communication between EV and EVSE

Source: ISGF

1.3.3 EVSE POWER STANDARDS

The committee formed under the Ministry of Heavy Industries has issued a standardised protocol for EV-charging infrastructure named as "Bharat Public Charger Specifications" with detailed specifications of public AC and DC chargers. In addition, the communication architecture has also been specified with OCPP being considered as the communication protocol for public off-board chargers.



EV-EVSE communication	**EVSE-CMS communication**	**CMS-Mobile app communication**
To guarantee safe and secure supply of energy for battery charging	To handle grid-related parameters, authorisation & metering at different rates, charger reservations, etc.	For locating nearest charging stations, billing details based on Vehicle Identification Number etc.

CMS – Central Management System

UI – User Interface

The Open Charge Point Protocol (OCPP) is an internationally established open protocol for the communication between EV-charging stations and charging station networks (akin to a cell phone service provider). OCPP tells the charging station to communicate and send data to a particular EVSE service provider (EVSP) or operating company's charging station management software.

The electric 2, 3 and 4 wheelers in India do not have an EV charger beyond 2.5 to 3kW, with 230V single-phase charging point requirement, on board so as to make the vehicles affordable. These AC 2.5–3kW could fast charge a 2-wheeler in an hour's time and a 4-wheeler with 12kWh battery in five to six hours.

Whereas, the DC public off-board chargers are classified as:

- Level 1 DC chargers with output voltage of 48 volt/72 volts and power output of 10kW to 15kW with maximum current of up to 200A
- Level 2 DC chargers with output voltage of 1000 volts with power output of 30kW/150 kW

In December 2018, Bureau of Indian Standards (BIS) came out with a charging infrastructure standard called 'IS: 17017', which recommends India to adopt both CCS and CHAdeMO standards and Type-2 AC with Rated Voltage (V), having range of 200 to 1,000V for fast charging while also allowing GB/T for the Chinese-standard compatible electric vehicles.

1.3.4 MOTORS

TABLE-7: BLDC Motor Specifications for e-rickshaws

BLDC Motor Specifications for e-rickshaws	
Input Voltage	48 volts
Motor's Power Rating	800-1200 watt
Motor Warranty	6 months
Controller	24 MOSFET (Metal Oxide Semiconductors Field Effect Transistors), 50 amperes
Source: ISGF	

Motors in the EV is the backbone of the propulsion system which converts electrical energy received from the battery into mechanical energy; thereby powering the movement of the vehicle. There are different types of motors used in EVs, e.g. brushless DC motor, switched reluctance motor (SRM), induction motor (IM), etc. Permanent-magnet- (PM) assisted-switched-reluctance motor or axial-flux-ironless-permanent magnet motor are the most advanced type of motors which has higher efficiency, better power density, low loss, etc. These are used by high end cars like BMWi3 or Renovo Coupe. The brushless DC motors (BLDC) are, on the other hand, more commonly used in e-rickshaws, but they suffer from short constant power range, decreased torque with increase in speed, etc. The tables below show power and efficiency comparison of various types of motors.

Power Comparison of different motors:

TABLE-8: Power Comparison of different motors

Motor Type	Power (kW)		Base Speed (rpm)	Maximum Speed (rpm)
	Hybrid EV	Battery-powered EV		
IM	57	93	3000	12000
SRM	42	77	2000	12000
BLDC	75	110	4000	9000
Source: ISGF				

Efficiency comparison of different motors:

TABLE-9: Efficiency comparison of different motors

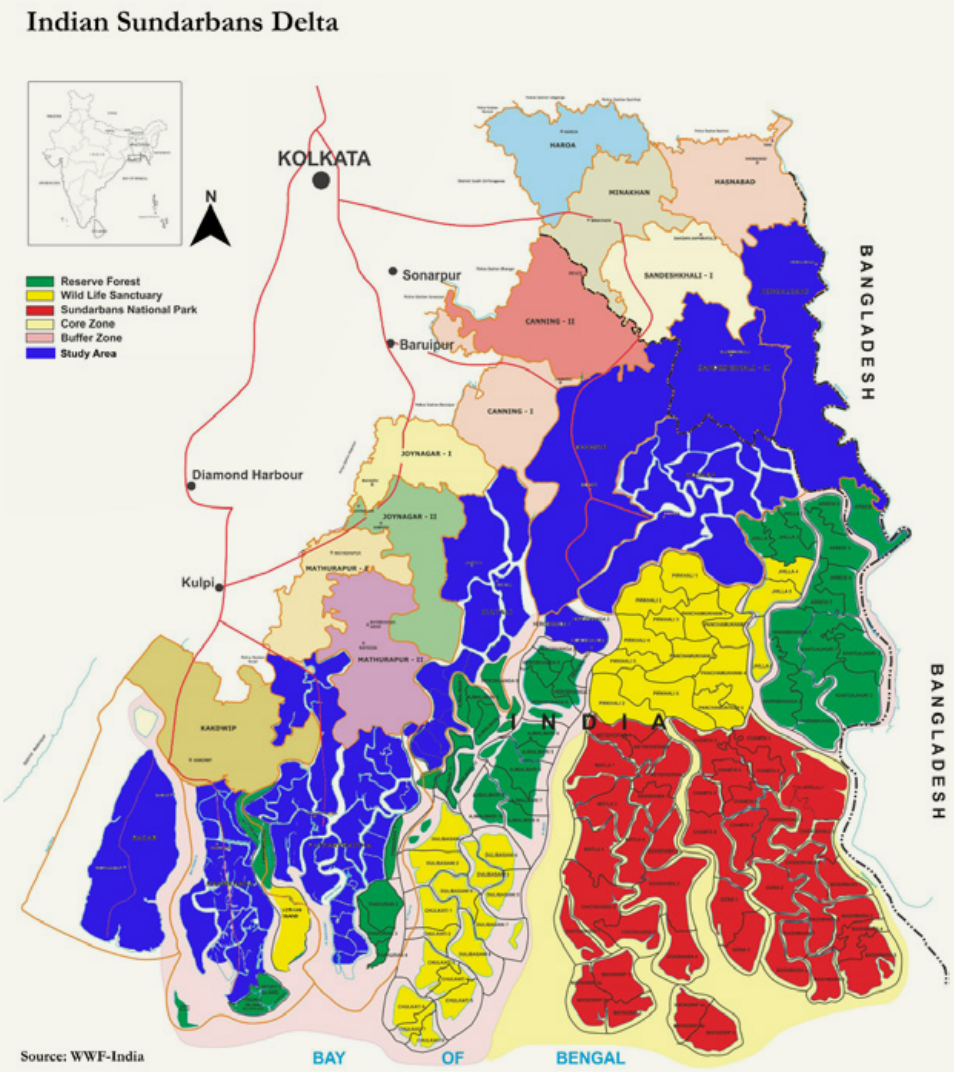
Motor Type	Peak Load Efficiency (%)	Efficiency at 10% Load (%)
IM	>90	>90
SRM	<95	>90
BLDC	>95	70-80
Source: International Journal of Research in Engineering and Technology - Comparison of electric motors for electric vehicle application		

With fast advancement in technology in terms of battery composition, performance, charging rate, increased efficiency of motors, efficient charging, etc. and reduction in their cost, (For e.g., the ***cost of Lithium ion batteries has come down by 80% from 2013 to 2018)*** the EV is transforming itself from a highly priced product to a low-cost product. Moreover, the improvement in charging standards is also facilitating the notion of interoperability which will in turn play an important role in providing a massive push to the EV adaptability process.

2. INDIAN SUNDARBANS: AN OVERVIEW

The Indian Sundarbans, part of the Ganga-Brahmaputra-Meghna basin, is a network of low-lying islands in the Bay of Bengal. It is bounded by the Ichamati-Raimangal river in the east, the Hugli river in the west, the Bay of Bengal in the south, and the Dampier Hodges line in the north. It has a total land area of 9630 sq. km, with 4260 sq. km covered by forest and the rest inhabited by humans. It is divided into 19 CD blocks with six blocks in North 24 Parganas; namely Haroa, Sandeshkhali I&II, Hingalganj, Hasnabad and Minakhan. It is divided into 13 blocks in South 24 Parganas, namely Sagar, Namkhana, Kakdwip, Patharpratima, Kultali, Basanti, Gosaba, Canning I & II, Mathurapur I & II and Jaynagar I & II. The inhabited area comprises 54 islands

FIGURE-3 Areas identified in the Indian Sundarbans Delta for study



(5,370 sq. km) with a population of more than 4.4 million (World Bank, 2014). For this project, the main focus has been on the forest fringe island parts of the Sundarbans, e.g. Patharpratima, Kultali, Basanti, Gosaba, Sagar, Namkhana, Sandeshkhali and Hingalganj, to carry out the study.

The interconnection of these islands as well as connectivity with the mainland is mainly through tidal rivers, creeks and canals. Therefore, existing authorised modes of transport such as railways and buses cannot reach these remote islands, making ferries and engine-based tri-cycles the only option for last-mile connectivity in these areas. However, these engine-based tri-cycles are not certified by the Automotive Research Association of India (ARAI), nor legally recognised by the Transport Department as these are made of used parts of some old or broken down vehicles and are highly unstable. Moreover, as these engine vans are not legally recognised, individuals cannot claim insurance or compensation in case of any accidents.

According to a survey undertaken by WWF-India in 2011, there are thousands of engine-based tri-cycles and hundreds of ferries being used today as means of transportation in the forest-fringe island parts of the Sundarbans. This results in GHG emission of approximately 8000 tonnes per year (4000 tonnes per year by engine based tri-cycles & 4000 tonnes per year by ferries).

Being an ecoregion of global importance, the government has taken initiatives for improvement in electrical infrastructure, promotion of renewable energy-based systems, development of roads, etc. which are prerequisite for socio-economic development. However, the local transport system in these areas still depends on unsustainable and unsafe modes of transportation. This has also resulted in the degradation of air quality in the Sundarban islands. Therefore, in order to address the environmental concern and with clean energy in place, the Sundarbans region needs a more sustainable transportation system in both surface and water transport. Electric mobility is the most preferred solution to achieve this vision. However, effective implementation and large-scale adoption of these electric vehicles will depend on the following key factors.

Power Supply Availability
- Continous power supply for charging of these vehicles & distribution network to facilitate this

+

Effective Institutional Mechanism
- Proper guidelines for electric vehicle registration and to regulate it under Motor Vehicles Act

+

Financing Availability
- Easy processing and low interest loan for electric vehicle

2.1 POWER SUPPLY POSITION

TABLE-10: Power Distribution Capacity in Sundarbans

Substation	*Capacity (MVA)*
Hingalganj	10
Sarberia	6.3
Gosaba	6.3
Kakdwip	25.2
Namkhana	14.45
Sonakhali	18.9
Jamtala/Kultali	16.3
Source: Department of Power, West Bengal	

The Sundarbans, which is home to 4.4 million people, depended on kerosene, candles and forest biomass for cooking and lighting for a long time. Under the ongoing programs of the Government of India, such as Integrated Power Development Scheme (IPDS), Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) and SAUBHAGYA, it is expected that the target of the 100% electrification of the Sundarbans as well as 100% household electrification will be achieved in 2019. The ***Government of India has sanctioned a project cost of approx. INR 259 crore (2.59 billion) under Saubhagya scheme and approx. INR 4262 crore (42.62 billion) under Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) for the completion of 13 projects to strengthen the distribution network in West Bengal.***

TABLE-11: Village electrification under DDUGJY (X, XI, XII and new projects) for North & South 24 Parganas

Village electrification under DDUGJY (X, XI, XII and new projects) for North & South 24 Parganas	
Installation new DTR (nos.)	3280
Drawing of new 11 kV spur line of DTR (km)	5068
Drawing of new LT AB cable (km)	5226
Source-DDUGY & Saubhagya	

The distribution grid infrastructure in the Sundarbans is owned by the West Bengal State Electricity Distribution Company Limited (WBSEDCL). It receives bulk power at 33kV sub-stations which then gets distributed on 11kV lines (large industrial load fed at 11kV or 33kV), which are further stepped down from 11kV to secondary voltages at 415V using DTs to the consumers in the Sundarbans. Various new sub-stations were also built to strengthen the network and to address the power-quality issues due to feeder lines supplying at a long distance. In addition, a higher number of distribution transformers, mainly with ratings of 25kVA and 63kVA have been installed to address the overloading problem, increasing losses, etc. For example, a 6.3 MVA sub-station has been built in Gosaba to address the power-quality issues and recently another 132/33kV gas insulated sub-station at sub-transmission level has also been installed and commissioned in Sonakhali.

On rural electrification, out of 37,960 number of villages, WBSEDCL has undertaken electrification of all the villages (including the Sundarbans) and also provided electricity to 34,57,285 numbers of rural BPL/APL households. It has undertaken various project activities under schemes like Sagar Island Scheme, Sundarbans Development Board Fund, Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGVY). For example, 14 villages are electrified and 59 partially electrified villages are intensified in Gosaba, Patharpratima and Namkhana Block, and another 80 revenue villages have been electrified out of 84 revenue villages in Gosaba, Patharpratima, Mathurapur II and Kultali Block.

TABLE-12: Progress of Rural Electrification Schemes in the Sundarbans

Sl. No.	*Name of rural electrification scheme*	*Number of households energised (including the Sundarbans region)*	
		Below poverty line (BPL)	*Above poverty line (APL)*
1	***RGGYVY (X Plan)***	92,835	62,821
2	***RGGYVY (XI Plan)***	20,98,556	No scope
3	***WB Rural Electrification Program***	7,42,355	No scope
4	***RGGYVY (XII Plan)***	32,013	3,60,931
5	***Sagar Island***	250	30,800
6	***DDUGY***	144	7556

Source - WBSEDCL

Apart from conventional grid electricity, there are various renewable energy generating plants operating in the Sundarbans area, which are supplying power to the households on remote islands. West Bengal Renewable Energy Development Agency (WBREDA) has developed various standalone and micro-grid based solar power plants along with biomass (500kW in Gosaba), windfarm (8 x 250kW in Fresergunj) and proposed tidal plants (3.6MW) in remote areas of the Sundarbans to cater to their basic electricity needs. Some standalone solar projects for schools, hospitals and other critical infrastructures have also been implemented. Today, most of these RE plants are non-functional but could be refurbished to support electric vehicle charging stations in remote islands in consultation with both WBREDA and Panchayat Samitis, to whom these energy systems have been handed over. In addition, WWF-India has also developed community operated and managed AC and DC solar micro grids along with its knowledge partners CAT International Projects and Schneider Electric India Foundation in Satjelia and Kumirmari Islands, connecting over 650 households, rural institutions and some small businesses.

TABLE-13: List of a few power plants in the Sundarbans (mini grid)

Some power plants in Sundarbans (mini and micro grids)	
Tushkhali, Sandeshkhali II	110kWp
Pathankhali, Gosaba	55kWp
Indrapur, Patharpratima	110kWp
Mandirtala, Sagar	28.5kWp
Kaylapara, Sagar	110kWp
Mahendraganj, Sagar	25kWp
Mritunjoynagar, Sagar	26kWp
Rakhalpur, Patharpratima	110kWp
Hingalganj Hospital, Hingalganj	5kWp

Source - WBREDA

The power supplied from these renewable sources along with grid electricity can be utilized for the charging infrastructure depending on the location. As the focus is mostly on the electrification of surface transport, i.e. mainly the engine-based carts or tri-cycles, home-based charging with commercial meters or 1kW to 2kW chargers can be utilized for charging the batteries of the e-rickshaws. Integration of electric vehicles charging with renewable energy will provide the impetus to clean and sustainable aspects of the transport sector. ***Recently, WWF-India completed the installation of two 5kWp electric vehicle solar charging stations in partnership with Lahiripur and Satjelia Gram Panchayats. These electric vehicle charging stations are connected by a 7 km-long stretch of road on which electric vehicles (e-rickshaws) are operating on a daily basis***. Moreover, the Sundarbans being a tourist destination, a clean transportation system will not only help in maintaining its eco heritage, but will also attract more tourists through its clean and green image and by providing a safe and sustainable transportation system.

2.2 INSTITUTIONAL STRUCTURE

Institutional mechanisms facilitating the adoption of standard and certified e-rickshaws is one of the key factors which can accelerate the deployment of electric vehicles in the Sundarbans area. The administrative set up in the Sundarbans area consists of Zilla Parishad, Panchayat Samiti and Gram Panchayat, who are responsible at various levels for planning and implementation of different rural development programs.

TABLE-14: Institutional Structure in Sundarbans

Development Level	*Institutions responsible*	*Peoples' Representative*	*Government officials*
Village Level	Gram Panchayat	Pradhan	Executive Assistant and village level workers
Block Level	Panchayat Samiti	Sabhapati	Block Development Officer
District Level	Zilla Parishad	Sabhadhipati	District Magistrate

Development Level	*Institutions responsible*	*Peoples' Representative*	*Government officials*
District Level	Regional Transport Office	Regional Transport Officer	
State Level	West Bengal Transport Corporation	Managing Director	

Source: UNDP

A large number of e-rickshaws/models plying in the state don't have a type-approval certificate from the GoI-authorised test agencies like ICAT, ARAI, etc. These are not legalised currently and the number of e-rickshaws plying in the Sundarbans area is very small, leading to no proper institutional mechanism being put in place to support the deployment. However, once the policy and regulatory guidelines from the Ministry of Transport, Govt. of West Bengal are put in place to ensure usage of standard and certified e-rickshaws, the administrative machinery has to be proactive in facilitating the deployment of e-rickshaws in the area.

The Gram Panchayat, being the core of the grassroot level governance system, needs to be the focal point for facilitating the deployment of e-rickshaws in the area. This can be done by educating the villagers on benefits of e-rickshaws, educating the owners about the requirement for registration and facilitating the registration process, and also taking responsibility of monitoring any operational issues related to administration, post deployment of e-rickshaws at large scale at the village level.

The Regional Transport Offices at the district level, in consultation with State Transport Authority, should prepare guidelines for the e-rickshaw registration process along with the list of documents required for registration, which includes validation of type-approval certificate issued by GoI-authorised test agencies. The development of separate insurance-related procedures and green number plates for electric vehicles are also required and guidelines need to be set up, as suggested by the central government. These activities can be spearheaded by Regional Transport Offices in consultation with other government agencies.

Documents required for registration of e-rickshaws

- Application for registration
- Certificate of Roadworthiness (from manufacturer)
- Manufacturer's invoice
- Certificate of Fitness
- Certificate of Insurance
- Dealer's Invoice
- Residence proof

On the other hand, if any scheme is being launched by the government on deployment of e-rickshaws, like subsidy for buyers of e-rickshaws or allotment of fixed number of e-rickshaws to each Gram Panchayat, then the Zilla Parishad at district level and Panchayat Samiti at Block level along with District Magistrate and Block Development Officer should undertake the planning and implementation strategy. They should also monitor the implementation of the scheme at their respective administrative level.

2.3 FINANCING AVAILABILITY

Another factor that will be crucial for mass adoption of electric vehicles in the Sundarbans area will be easy availability of financial loans for the buyer of those vehicles. According to a journal by the National Center for Biotechnology Information (2016), almost 47% of the population are historically marginalised groups, 40% of the households live below poverty line and 13% are declared officially "poorest of the poor". Therefore, considering the financial condition of the population residing in the Sundarbans area, it is evident that financial support through bank or cooperative loan is necessary to encourage the locals to invest in the electric vehicle. As engine vans do not conform to the country's motor vehicle rules, it is very difficult for the engine van operators to get loans from the banks or microfinance institutions. The same goes for e-rickshaws without type-approval certificate from authorised test agencies as these vehicles are also not legally recognised. However, with the inclusion of standard and certified e-rickshaws under the ambit of motor vehicle rules; government schemes like Gatidhara, bank loans for commercial vehicles can be made applicable to these e-rickshaws. Some of the schemes are discussed in the section below.

GATIDHARA SCHEME

The Gatidhara scheme has been introduced by the Government of West Bengal to facilitate employment through the transport sector by providing subsidies and easy financing to purchase commercial vehicles. It provides financial assistance in the form of a term loan (65% of the cost of the vehicle) from any nationalized bank, cooperative or gramin bank and also provides 30% of the cost of the vehicle as subsidy up to a maximum of INR one lakh. The applicant to this scheme should also contribute 5% of the cost of the vehicle as margin money and will be required to repay the loan in 5 to 7 years. Some of the salient features of the scheme that make it suitable for e-rickshaw implementation in the Sundarbans area are:

Low interest rate similar to other government schemes + Applicable for people having family income less than INR 25,000 per month + People availing loan under BKSP or UKSP (scheme for employment) are also eligible for Gatidhara

However, as the applicant needs to provide a driving license and the vehicle needs to be registered with the Regional Transport Office, financial assistance for the purchase of e-rickshaws will only be possible after these vehicles come under the ambit of legal procedures or are authorised by the government agencies.

PRADHAN MANTRI MUDRA YOJNA (PMMY)

Pradhan Mantri Mudra Yojna, a flagship scheme under the Government of India, provides loans up to INR 10 lakhs for non-farm income-generating activities. It provides loans under three categories, Sishu, Kishor and Tarun, with loan amounts ranging up to INR 50,000, INR 50,000 to INR 5 lakhs and INR 5 lakhs to 10 lakhs, respectively. It has ***27 public sector banks, 31 regional rural banks, 17 private sector banks, 36 microfinance institutions, 25 non-banking financial institutions and four co-operative banks*** on board for loan disbursement.

Under this scheme, there is a loan category for land transport which covers the purchase of e-rickshaws. The interest rate on the loan depends on the policies of the bank or financial institution from where the loan is being granted. The repayment period can also be extended to five years, if required, with consent from the bank and it provides additional facilities like no processing fee and no collateral. However, it requires that the applicant should not be a defaulter of any bank and that the person should provide identity and residential proof along with the quotation of the item to be purchased to avail the loan.

PNB GREEN RIDE FINANCING SCHEME

This scheme has been started by Punjab National Bank to facilitate transport operators and individual e-rickshaw owners by providing loans on both vehicle cost and battery replacement without any collateral and third-party guarantee. It provides loans up to ***85% of the invoice cost of the vehicle or 80% of the on-road price, whichever is less, and also supports battery replacement by providing a loan of up to 85% of the battery replacement cost after both first and the second year.*** However, it requires a margin of 15% on the vehicle's invoice cost, 20% of the vehicle's on-road price and requires 15% as margin for battery replacement both in the first and second year. The suggested loan repayment period is 33 months and the vehicle will be hypothecated to the bank as security till the loan repayment is completed.

SCHEMES UNDER BANGIYA GRAMIN VIKASH BANK

Bangiya Gramin Vikash Bank has been established as an Indian Regional Rural Bank sponsored by the United Bank of India. It provides various schemes under which small entrepreneurs can have access to different loans to purchase their vehicles, like loans for MSME under which small road and water transport operators are included.

SWAROZGAR CREDIT CARD

The Swarozgar Credit Card scheme provides loans to self-employed persons, micro entrepreneurs, rickshaw owners, fishermen, etc. to meet their investment requirements. They extend a composite loan of INR, 25,000 per borrower that can be increased on a case-by-case basis. The borrower can use the loan amount either as a term loan or working capital or a combination of both and has to repay the loan in five years along with interest, the rate of which varies from time to time. The credit card will be valid for five years, subject to performance of the account and needs to be renewed every

year through a simple review process. ***This scheme can be very helpful for people wanting to invest in e-rickshaws as this will give them an initial amount for partial investment, and there is a provision for an increase in the loan on a case-by-case basis. The requirement of e-rickshaws both from a business and a sustainability viewpoint in the Sundarban region provides a suitable business case to raise the loan amount for this kind of investment***.

LOAN FOR MSME

This loan is provided for micro and small enterprises, a helpful move for the masses. It can be started with a relatively lower investment and without requiring special skills on the part of the entrepreneurs, viz. manufacturing or service-related activities which require investment in equipment. The loan amount varies from INR 10 lacs to INR 2 crores (20 million) depending on the size of the business. Small road and water transport operators fall under this category and can have access to loans under this scheme. The repayment period for the loan ranges between five to seven years. ***This loan is suitable for people of the Sundarbans, as this scheme will help them develop their business if they are willing to invest in multiple road- and water-transport electric vehicles and crafts.***

SELF HELP GROUP

Micro finance through Self Help Group (SHG) has become a success story in rural India where a minimum of 10 people and maximum of 20 can form a group and deposit a part of their savings in the bank. In return, the bank provides a loan to the SHG which is six times the deposit amount. The interest rate for the loan is as high as 11%, however, on returning the loan on time (ranging from 3 to 7 years), an amount equivalent to 9% interest will be refunded to the SHG. The SHG can use this loan amount for income generation through investment in business activities. In the context of electric vehicles, women in SHGs can purchase electric vehicles with this loan amount and use it for business purposes. ***This will serve the multiple aims of women employment, gender diversity and cleaner transport***.

SAMABAY KRISHI UNNAYAN SAMITI

Samabay Krishi Unnayan Samiti (SKUS) also provides loans to self-help groups, six times the size of their savings, to start their own business. In addition to that, SKUS also has the mandate to invest their money for the development of rural areas. ***Estimating the cost of an e-rickshaw as INR 1,20,000, SKUS in G Plot Panchayat in Pathar Pratima CD Block has provided a loan of INR 80,000 per e-rickshaw at 18% interest for 3 and a half years and also provides for the maintenance of those e-rickshaws to promote the usage of electric vehicles in the area. As the e-rickshaw will be procured by SKUS, the loan beneficiary will also need to deposit INR 40,000 to SKUS at the beginning. In addition, the loan beneficiary also has to provide INR 700 per week as a part of the loan repayment to SKUS. The loan amount to be disbursed can also vary on the upside on a case-by-case basis.***

WEST BENGAL SC, ST AND OBC DEVELOPMENT AND FINANCE CORPORATION

West Bengal SC, ST and OBC Development and Finance Corporation is a State Channelizing Agency (SCA) for the National Scheduled Castes Finance and Development Corporation (NSFDC) which provides loans to Scheduled Caste (SC), Scheduled Tribe (ST) and Other Backward Class (OBC) people to start their own businesses, vocational training and skill development, education, etc. Under their Green Business Scheme, NSFDC provides loans to families whose annual income is up to INR 98,000 in rural areas and INR 1,20,000 in urban areas. As part of this scheme, NSFDC would provide need-based loans considering margin money provided by SCA, state and central subsidies and will provide 90% of the unit-cost loan, provided unit cost does not exceed INR 2 lakhs. The financial assistance will be channelized through SCAs, who will be charged one percent interest for projects up to INR one lakh and two percent by NSFDC for projects more than INR one lakh. SCAs in turn will charge three percent from the beneficiary for projects up to INR one lakh and five percent for projects that are more than INR one lakh. The repayment period for the loan is six years, including six months as moratorium period. In addition, 120 days moratorium is provided to SCAs for fund utilization. ***A few e-rickshaws are already running in the Hingalganj area, after availing the benefits from this scheme. It can be utilized by most of the population in the Sundarbans area who mostly belong to SC, ST and OBC category***.

Apart from these financing schemes, vehicle loans from nationalized and private banks can be made available provided that e-rickshaws are standard and certified and regulated with proper institutional mechanisms.

Considering the above strategic elements which are essential for the mass level deployment of e-rickshaws in the Sundarbans area, implementation-level assessment is also necessary in terms of route assessment to evaluate number of vehicles plying on the route, tariff, passenger density, etc.; grid upgradation requirement to support the envisaged load for e-rickshaw charging, and operating cost comparison with the currently plying engine vans, to evaluate the monetary benefit that the owner of these engine vans will realise on switching over to e-rickshaws.

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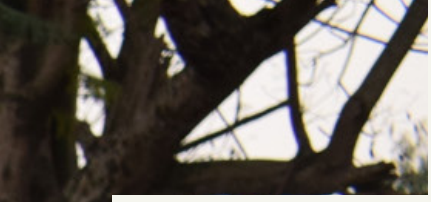

3. EV TRANSITION: ISGF ASSESSMENT

Considering this project's objective to carry out a feasibility study and to develop an action plan for introducing electric vehicles in the island parts of the Indian Sundarbans, eight different routes from each of the eight CD Blocks of the Sundarbans region were selected. The routes were identified from a survey carried out by WWF-India in 2011 on the number of engine vans plying in different routes across various blocks in the Sundarbans. The parameters for selection were route length, number of vehicles plying on that route, passenger volume for engine vans on those routes, availability of critical infrastructure like schools, hospitals, banks on the route, last-mile connectivity and connectivity to markets, ferry ghats, etc. The routes along with their route length, number of engine vans operating along those routes and respective electrical substations (33/11kV) responsible for distributing power in those areas are given below:

TABLE-15: Details of routes selected for study

District	Community Development Block	Route	*Route Length (in kms)*	*No. of engine vans operating*	*Electrical Substation*
North 24 Parganas	Sandeshkhali	Tushkhali to Duchnikhali	6	80	Sarberia
South 24 Parganas	Kultali	Jamtala to Vasha Panch Matha More	30	60	Jamtala
South 24 Parganas	Basanti	Sonakhali to Jhorkhali	22	50	Sonakhali
South 24 Parganas	Gosaba	Satjelia Bazar to Ashram More	12	60	Sonakhali
North 24 Parganas	Hingalganj	Jogeshganj to Samsernagar	12	50	Hingalganj
South 24 Parganas	Namkhana	Tekar Bazar to Namkhana	6	30	Kakdwip
South 24 Parganas	Patharpratima	Tater Bazar to Indrapur Van Stand	6.5	26	Kakdwip
South 24 Parganas	Sagar	Chak Phuldubi to Mrityunjaynagar	10	15	Kakdwip

Source: ISGF

ISGF has also carried out a survey on these routes and consulted various stakeholders, including WBSEDCL engineers, to understand matters like the operating cost and revenue estimate, number of trips completed by engine vans in a day, availability of power supply from the grid, and administrative support from the Gram Panchayat. Based on this survey, the assessment of the above aspects has been carried out and mentioned below for each of the selected routes. In addition to this, a cost and revenue

calculation for both engine van and e-rickshaw has been carried out to assess the financial viability of substituting engine vans with e-rickshaws. The calculations were made for a typical route length of 10km; and also for e-rickshaws with both Lithium-Ion battery and Lead-Acid battery.

TABLE-16: Cost comparison for an engine van and e-rickshaw with Lithium-Ion battery of 4kWh

For 1st Year			
Engine Van		***E-rickshaw***	
Parameters	***Amount***	***Parameters***	***Amount***
Cost of engine van	1,20,000	Cost of e-rickshaw	1,80,000
		Cost of charger/e-rickshaw	8,000
Vehicle maintenance cost for 1 year	9,500	Vehicle maintenance cost for 1 year	8,000
		Battery replacement cost	0
Registration and Road Tax	NA	Registration and Road Tax	8,500
Insurance	NA	Insurance	5,000
Other taxes	NA	Other taxes	1,500
Mileage (km/ltr)	18	Mileage (km/kWh)	20
Driver's Wages per year	90,000[4]	Driver's Wages per year	90,000
Distance driven per month (km)	1000	Distance driven per month (km)	1250
Cost of diesel (INR/ltr)	75	Cost of electricity (INR/kWh)	5.26
Working days	25	Working days	25
Fuel cost/year = {(1000*12)/18}*75= 50,000		***Electricity Cost/year = {(1250*12)/20} *5.26 = 3,945 (approx.)***	
Total cost: CAPEX= 1,20,000 OPEX/year= 9,500 + 50,000 + 90,000 = 1,49,500		***Total cost: CAPEX= 1,80,000 + 8,000 + 8,500 = 1,96,500 OPEX = 8,000 + 5,000 + 1,500 + 3,945 + 90,000 = 1,08,445***	
Fare per trip per passenger	20	Fare per trip per passenger	20
Number of passengers per trip	8	Number of passengers per trip	7
Number of trips per day	4	Number of trips per day	5
Revenue per year = 20*8*4*25*12 = 1,92,000		***Revenue per year = 20*7*5*25*12 = 2,10,000***	
Net Revenue = 1,92,000 - 1,49,500 = 42,500		***Net Revenue = 2,10,000 - 1,08,445 = 1,01,555***	
Payback Period = CAPEX / Net Revenue= 1,20,000/42,500 = 2.82 years = 2 years 10 months		***Payback Period = CAPEX / Net Revenue= 1,96,500/1,01,555 = 1.93 years = 1 year 11 months***	
Cost per km = {1,20,000 + (9,500*5) + (90,000*5) + (50,000*5)} / (1,000*12*5) = 14.46		***Cost per km = {1,80,000 + 8,000 + (8,000*5) + (3,945*5) + 8,500 + 6,500 + (5,000*4) + (90,000*5) + (1,500*5)} / (1,250*12*5) = 9.86***	
****All figures are in INR***			
Source: ISGF			

4 Minimum Wages at the rate of INR 300/day for 25 days a month (300*25*12=90,000)

In the above calculations, we have taken one extra trip for e-rickshaws. This is because, it is a long-distance route and e-rickshaws can afford to travel some kilometres without passengers (due to low operating cost) and can take passengers in between instead of wasting time in queue at the van stand. In addition, maintenance cost has also been taken on the higher side to factor in any cost which was not accounted for.

The table below shows the fixed and operating cost and revenue comparison between e-rickshaws with Lead Acid battery and engine vans. ISGF always encourages the use of Lithium Ion batteries instead of Lead Acid batteries, as recycling of the latter has potentially negative impacts on human health and the environment in the form of food poisoning, ground water pollution, etc., as lead and sulfuric acid present in these batteries are not only corrosive but can also easily contaminate soil and ground water. Though e-rickshaws with Lead Acid battery do offer a quick alternative to engine vans, ISGF does not encourage it due to the aforementioned health and environmental issues.

TABLE-17: Cost comparison for an engine van and e-rickshaw with Lead Acid battery of 5 kWh

For 1st Year			
Engine Van		***E-rickshaw***	
Parameters	***Amount***	***Parameters***	***Amount***
Cost of engine van	1,20,000	Cost of e-rickshaw	1,20,000
		Cost of charger/e-rickshaw	8,000
Vehicle maintenance cost for 1 year	9,500	Vehicle maintenance cost for 1 year	8,000
		Battery replacement cost	36,000 (need to replace the battery every year from second year onwards)
Registration and Road Tax	NA	Registration and Road Tax	8,500
Insurance	NA	Insurance	5,000
Other taxes	NA	Other taxes	1,500
Mileage (km/ltr)	18	Mileage (km/kWh)	14
Driver's Wages per year	90,000[5]	Driver's Wages per year	90,000
Distance driven per month (km)	1000	Distance driven per month (km)	1250
Cost of diesel (INR/ltr)	75	Cost of electricity (INR/kWh)	5.26
Working days	25	Working days	25
Fuel cost/year = {(1000*12)/18}*75= 50,000		***Electricity Cost/year = {(1250*12)/14} *5.26 = 5,635 (approx.)***	
Total cost: CAPEX= 1,20,000 OPEX/year= 9,500 + 50,000 + 90,000 = 1,49,500		***Total cost: CAPEX= 1,20,000 + 8,000 + 8,500 = 1,36,500 OPEX = 8,000 + 5,000 + 1,500 + 5,635 + 90,000 = 1,10,135***	
Fare per trip per passenger	20	Fare per trip per passenger	20
Number of passengers per trip	8	Number of passengers per trip	7
Number of trips per day	4	Number of trips per day	5
Revenue per year = 20*8*4*25*12 = 1,92,000		***Revenue per year = 20*7*5*25*12 = 2,10,000***	
Net Revenue = 1,92,000 - 1,49,500 = 42,500		***Net Revenue = 2,10,000 - 1,10,135 = 99,865***	
Payback Period = CAPEX / Net Revenue = 1,20,000/42,500 = 2.82 years = 2 years 10 months		***Payback Period = CAPEX / Net Revenue = 1,36,500/99,865 = 1.37 years = 1 year 4 months***	
Cost per km = {1,20,000 + (9,500*5) + (90,000*5) + (50,000*5)} / (1000*12*5) = 14.46		***Cost per km = {1,20,000 + 8,000 + (8,000*5) + (5,635*5) + 8,500 + 6,500 + (36,000*4) + (5000*4) + (1,500*5) + (90,000*5)} / (1250*12*5) = 11.10***	
Source: ISGF			**All figures are in INR*

5 Minimum Wages at the rate of INR 300/day for 25 days a month (300*25*12=90,000)

In the above calculation, we have taken one extra trip for e-rickshaws. This is because, it is a long-distance route and e-rickshaws can afford to travel some kilometres without passengers (due to low operating cost) and can take on passengers in between instead of wasting time in queue at the van stand. In addition, maintenance cost has also been taken on the higher side to factor in any expenses which were not accounted for. Additionally, the e-rickshaw charger cost can be waived off as the owner can charge at any public charging point by paying the required fees that comprises the electricity cost and a service fee.

The detailed route-wise assessment is mentioned in the next section. The detailed cost and revenue calculation for engine vans and e-rickshaws with Lithium Ion battery has also been mentioned in the Annexure.


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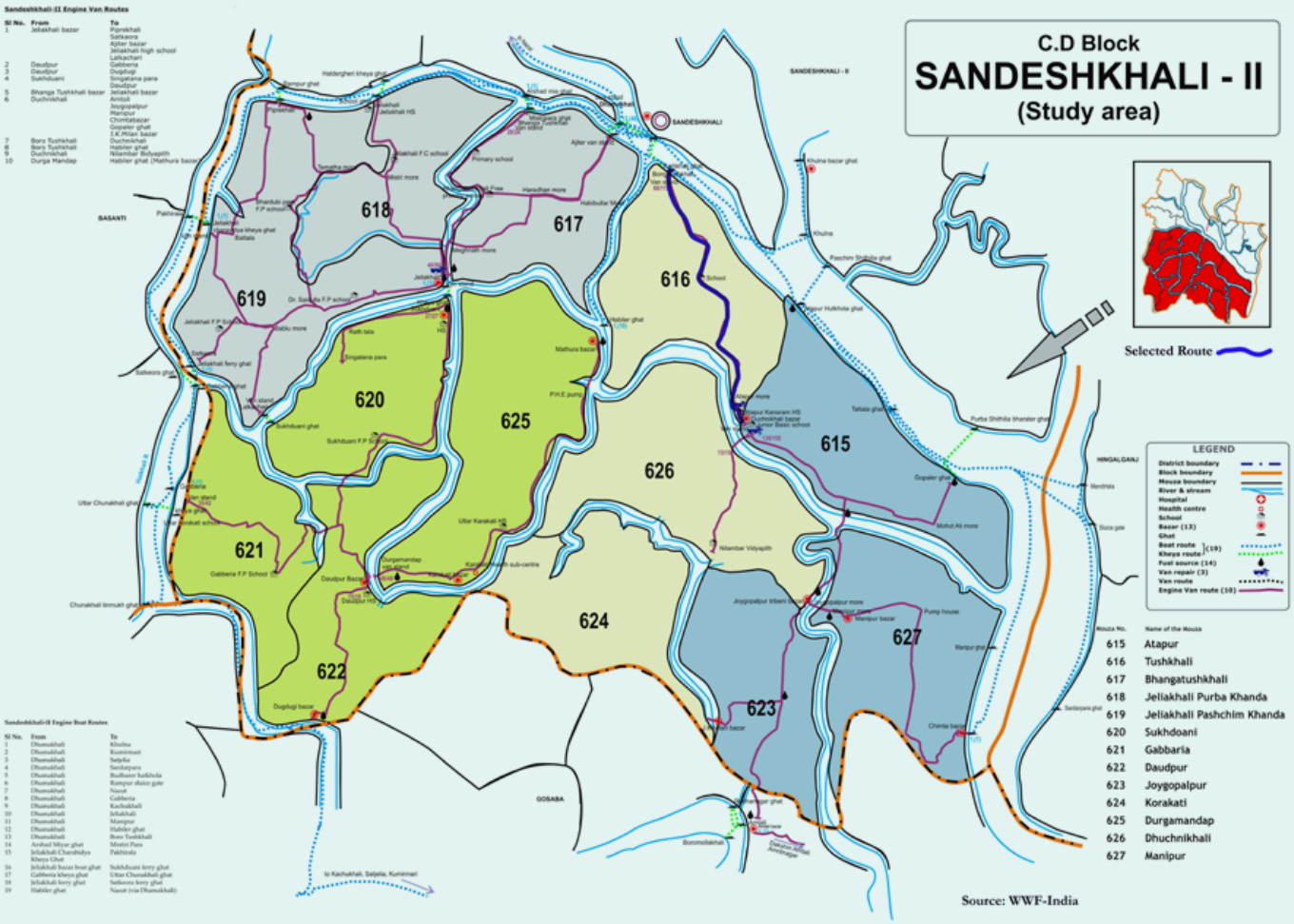
FIGURE-4 Route: Tushkhali – Duchnikhali, Sandeshkhali-II CD Block



3.1 TUSHKHALI – DUCHNIKHALI, SANDESHKHALI-II CD BLOCK

Tushkhali village is located in Sandeshkhali II block of North Twenty-Four Parganas district in West Bengal, India. It is situated 6.7km away from the sub-district headquarter, Kumarjola. The route Tushkhali to Duchnikhali connects the Tushkhali ferry ghat to Duchnikhali, a market place for the people living nearby. Moreover, the route also covers schools, including one Junior Basic School, Atapur Kenaram High School, etc. Although the road on the route is laid with both bituminous and brick materials, the road is in good condition and is wide enough to cater to two engine vans at a time. The thick blue line in the given map indicates the selected route.

Based on information derived from discussions with the engine van union secretary and the drivers of engine vans, there are currently 150 vans registered in the union for Tushkhali van stand. There are, however, 80 engine vans operating on a daily basis on the 6-km route. The number of trips undertaken by each van on a daily basis varies from four to six trips (if one considers Tushkhali to Duchnikhali and Duchnikhali to Tushkhali as different trips).

Considering e-rickshaws can travel 70km with a one-time full charge of battery, the distance of the route is 6km and the number of trips is six times, the e-rickshaw with single full charge can easily travel the required distance without any need for charging during the day. As a result, the operating cost for e-rickshaws will automatically come down, suggesting a better payback period for the e-rickshaws compared to engine vans. The detailed fixed and operating cost calculation has been provided in Appendix A-1.

On the electrical infrastructure side, the 132/33kV sub-station in Harishpur supplies power to the 33/11kV sub-station in Sarberia (6.3MVA). Through one of its feeders, it distributes power to the Tushkhali area; supplied to the consumer through a number of distribution transformers (DTs) of different ratings, e.g. 25kVA, 63kVA and 100kVA depending on the requirement in the area. There are 453 DTs (322 nos. of 25kVA, 126 nos. of 63kVA and 5 nos. of 100kVA) which supply power to all the areas falling under

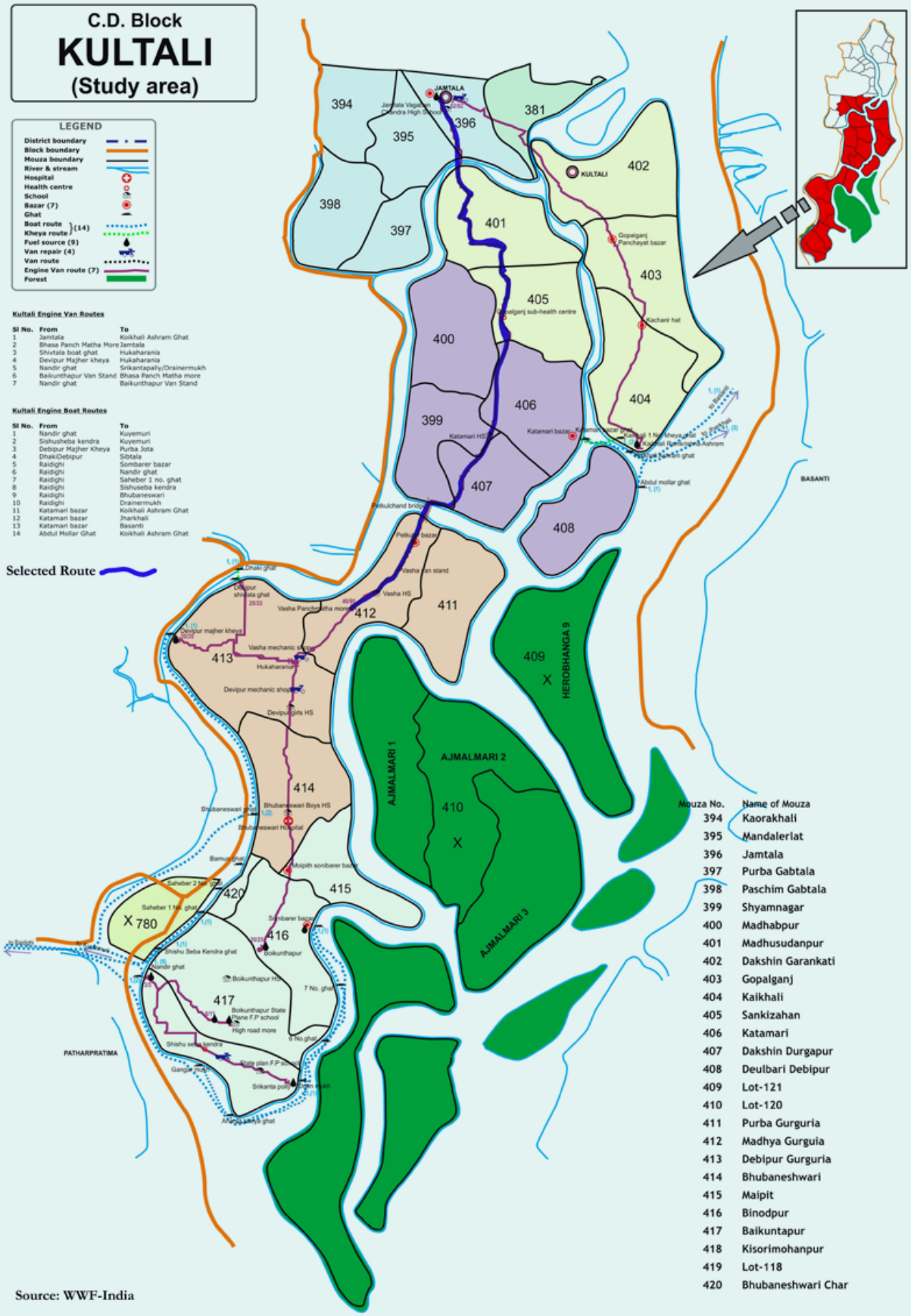
FIGURE-5: Discussion with engine van operators in Tushkhali – Duchnikhali route, Sandeshkhali-II CD Block

Sarberia sub-station including Jeliakhali and Gazikhali. A 110kWp solar power project has been installed in Tushkhali by WBREDA which can also be used for charging e-rickshaws, during the day.

It is proposed to introduce e-rickshaws in phases for this route, starting with batches of 20 e-rickshaws with 5kWh batteries which may be distributed 10 each at both ends of the route. The charging load of the 10 e-rickshaws at each end in a particular hour will be 50kW (10 x 5kWh). To begin with the 63kVA and 100kVA DTs may be able to support their charging in the early morning and late-night hours (full charging may be 3 hours, based on the battery type and make).

DT loading in the Tushkhali to Duchnikhali area varies between 60% to 30% during summer and winter, respectively, which suggests availability of spare capacity in the existing DTs to cater to the additional load of the first batch of 20 e-rickshaws. Deployment of more (beyond the initial batch of 20) e-rickshaws will increase the load and the DTs might need upgradation or establishment of charging stations at both ends of this route with separate DTs. Since most of the houses and commercial buildings in the area are electrified, it will enable home charging of e-rickshaws in the night. However, the power losses in the area is in the range of 80% and frequent power cuts in case of storm or rain are common, posing a challenge in terms of system reliability for the charging of e-rickshaws.

FIGURE-6 Route: Jamtala – Vasha Panch Matha More, Kultali CD Block



Source: WWF-India

3.2 JAMTALA—VASHA PANCH MATHA MORE, KULTALI CD BLOCK

Jamtala village is located in Kultali block, which is an administrative division in Baruipur sub-division of South 24 Parganas district in West Bengal. The route Jamtala to Vasha Panch Matha More connects the Jamtala bazar to Bhasha Panch Matha More, which is near Devipur Sivtala Ghat but also covers schools (like Jamtala Bhagawan Chandra High School and Katamari High School), hospitals and other well-frequented places like, Gopalganj Sub-Health Center and Petkuler Bazar. The route is down a bituminous road and is broad enough to cater to up to three vehicles at a time. The thick blue line in the given map indicates the selected route.

Based on information collected during discussions with the union secretary and drivers of engine vans, there are currently 300 vans registered with the union for this van stand, though only 60 engine vans operate on a daily basis in the route. However, since the route is very long — a distance of 30km, engine vans normally undertake one to two trips (Jamtala-Vasha Panch Matha More-Jamtala) and also if the number of passengers is low, these vans go to Panchu Master More instead of Vasha Panch Matha More from Jamtala, an easier distance of 10km that the vans can undertake 4 to 6 trips in this route (Jamtala-Panchu Master More–Jamtala).

Since an e-rickshaw can travel a distance of 70km with a one-time full charge of the battery, and since the distance of the route and number of trips are 30km and 2, respectively; the e-rickshaw with single full charge can easily travel the required distance without any need for charging during the day. As a result, the operating cost for e-rickshaws will automatically come down, suggesting a better payback period for the e-rickshaws as compared to engine vans. The detailed fixed and operating cost calculation has been mentioned in Appendix A-2.

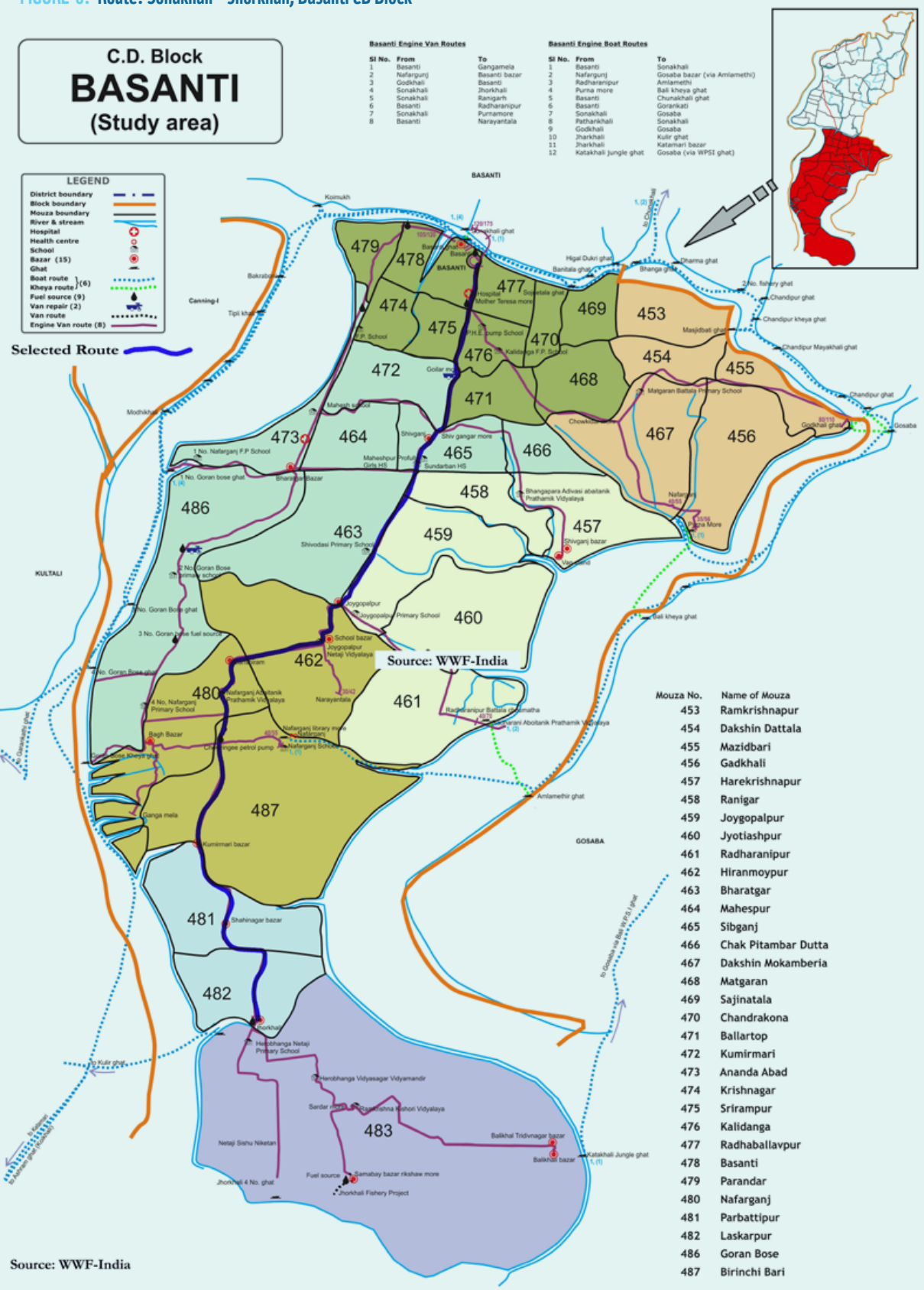
On the electrical infrastructure side, 16.3 MVA, 33/11kV sub-station in Jamtala through one of its feeders (4 feeders in 33/11kV sub-station) distributes power to the Jamtala area, which is supplied to the consumer through a number of distribution transformers (DTs) of different ratings e.g. 25kVA, 63kVA and 100kVA, depending on the requirement in the area. There are 700 distribution transformers with 356 nos. of 63kVA and 100kVA, and the remaining 344 DTs are of 25kVA which supply power to all the areas falling under Jamtala sub-station.

FIGURE-7:
Discussion with engine van operators in Jamtala - Vasha Panch Matha More route, Kultali CD Block

It is proposed to introduce e-rickshaws in phases in this route starting with batches of 20 e-rickshaws with 5kWh batteries. Ten each can be deployed at both ends of the route. The charging load of the 10 e-rickshaws at each end in a particular hour will be 50kW (10 x 5kWh). To begin with, the 63kVA and 100kVA DTs may be able to support their charging in the early morning and late-night hours (full charging may take 3 hours based on the battery type and make).

DT loading in the area varies between 70% to 50% during summer and winter, respectively, which suggests availability of spare capacity in the existing DTs to cater to the additional load of the first batch of 20 e-rickshaws. Deployment of more (beyond the initial batch of 20) e-rickshaws will increase the load and the DTs might need upgradation or charging stations may need to be established at both ends of this route with separate DTs. Since most of the houses and commercial buildings in the area are electrified, it will help home charging of e-rickshaws in the night. However, due to high power losses in the area to the tune of 83% and increased occurrences of DT failures (from 5 up to 20 such failures a month), continuous power supply is a concern in the area.

FIGURE-8: Route: Sonakhali – Jhorkhali, Basanti CD Block



3.3 SONAKHALI – JHORKHALI, BASANTI CD BLOCK

Sonakhali is a village under Basanti Police Station of Basanti Block, South 24 Parganas District in the state of West Bengal. Sonakhali is sub-district headquarter of Sonakhali village and has a geographical area of approx. 880 hectares. The route Sonakhali to Jhorkhali connects the Sonakhali ghat to Jhorkhali and covers 16 revenue villages en route. The route also covers various market places, schools and hospitals like Mother Teresa Hospital, Joygopalpur Netaji Vidyalaya, Sundarbans High School, School Bazar, Shahinagar Bazar, etc. Moreover, this is a convenient route for tourists going to Jhorkhali to sightsee in the Tiger Reserve Forest, among other places. The route is a mix of bituminous road and brick-paved road, though it is wide enough to cater to two vehicles at a time. The thick blue line in the given map indicates the selected route.

Based on information collected during discussions with the union secretary and drivers of engine vans, there are currently 84 vans registered with the union for this van stand, though only 50 engine vans operate on a daily basis in the route. The distance of the route is around 22km and the maximum number of trips these engine vans can undertake is only two (Sonakhali-Jhorkhali-Sonakhali), as the distance is too long and the vans returning after one trip have to wait for a considerable time due to the queue system.

Since an e-rickshaw can travel a distance of 70km with a one-time full charge of the battery and since the distance of the route and number of trips are 22km and 2 nos., respectively, an e-rickshaw with single full charge can easily travel the required distance without any need for charging during the day. As a result, the operating cost for e-rickshaws will automatically come down, suggesting a better payback period for the e-rickshaws compared to engine vans. The detailed fixed and operating cost calculation has been provided in Appendix A-3.

On the electrical infrastructure side, 18.9 MVA, 33/11kV sub-station in Sonakhali through one of its feeders (out of 6 feeders in 33/11kV sub-station) distributes power to the Sonakhali to Jhorkhali area. This is supplied to the consumer through a number of distribution transformers (DTs) of different ratings, for e.g. 25kVA, 63kVA and 100kVA depending on the requirement in the area. There are a total of 1066 distribution transformers with 857 nos. of 25kVA, 174 nos. of 63kVA and 35 nos. of 100kVA which

FIGURE-9:
Discussion with engine van operators in Sonakhali – Jhorkhali route, Basanti CD Block

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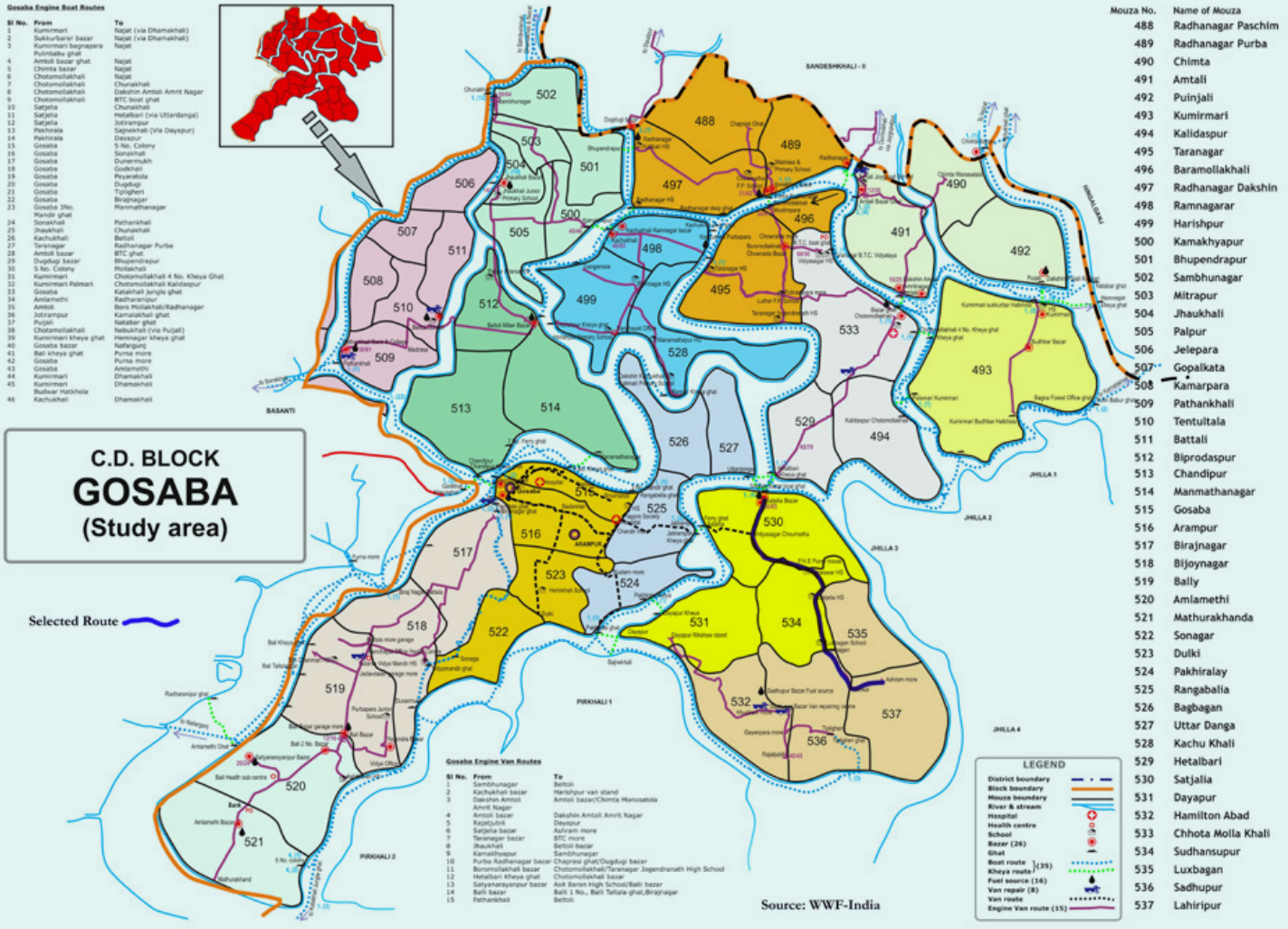
supply power to all the areas falling under Sonakhali sub-station. The feeder from Sonakhali to Jhorkhali is 40km long and provides power supply to 95,000 consumers in the area.

The introduction of e-rickshaws in phases is proposed on this route, starting with batches of 20 e-rickshaws with 5kWh batteries, with 10 being deployed at each end of the route. The charging load of the 10 e-rickshaws at each end in a particular hour will be 50kW (10 x 5kWh). To begin with, the 63kVA and 100kVA DTs may be able to support their charging in the early morning and late-night hours (full charging may be 3 hours based on the battery type and make).

With deployment of e-rickshaws, the electrical load will increase due to their charging load, so the DTs need to have spare capacity to accommodate the additional load. If not, separate transformers will need to be installed to cater to the envisaged increase in load. DT loading in the Sonakhali to Jhorkhali area varies between 80% to 50% during summer and winter, respectively, with 80% loading at the peak time, which suggests availability of spare capacity in the existing DTs to cater to the additional load. Since most of the houses and commercial buildings in the area are electrified, it will help home charging of e-rickshaws at night. However, due to high power losses in the area to the tune of 81% and the increased number of DT failures (30 nos. per month mainly during summer), continuous power supply is a concern in the area.

FIGURE-10: Route: Satjelia Bazar - Ashram More, Gosaba CD Block



Mouza No.	Name of Mouza
488	Radhanagar Paschim
489	Radhanagar Purba
490	Chimta
491	Amtali
492	Puinjali
493	Kumirmari
494	Kalidaspur
495	Taranagar
496	Baramollakhali
497	Radhanagar Dakshin
498	Ramnagarar
499	Harishpur
500	Kamakhyapur
501	Bhupendrapur
502	Sambhunagar
503	Mitrapur
504	Jhaukhali
505	Palpur
506	Jelepara
507	Gopalkata
508	Kamarpara
509	Pathankhali
510	Tentultala
511	Battali
512	Biprodaspur
513	Chandipur
514	Manmathanagar
515	Gosaba
516	Arampur
517	Birajnagar
518	Bijoynagar
519	Bally
520	Amlamethi
521	Mathurakhanda
522	Sonagar
523	Dulki
524	Pakhiralay
525	Rangabalia
526	Bagbagan
527	Uttar Danga
528	Kachu Khali
529	Hetalbari
530	Satjalia
531	Dayapur
532	Hamilton Abad
533	Chhota Molla Khali
534	Sudhansupur
535	Luxbagan
536	Sadhupur
537	Lahiripur

3.4 SATJELIA BAZAR - ASHRAM MORE, GOSABA CD BLOCK

Satjelia is a village in Gosaba Block in South 24 Parganas district in the state of West Bengal. It is located 9km from Gosaba and 75km from the district headquarters at Alipore. The route from Satjelia Bazar to Ashram connects five revenue villages: namely Satjelia, Sudhansupur, Luxbagan, Lahiripur and Sadhupur and provides the connectivity between Satjelia ferry ghat and Ashram more. The route also covers various schools like Luxbagan School, Satjelia High School and Yogeshwar High School, making it one of the busiest routes in the area.

The route is a mix of bituminous road and brick-paved roads and is wide enough to cater to two vehicles at a time. However, the road is in poor condition as in some areas the road is broken and can cause accidents and physical damage to the vehicle. The thick blue line in the given map indicates the selected route.

Based on information derived from discussions with the union secretary and drivers of engine vans, currently 60 engine vans normally operate on a daily basis in the route. The distance of the route is around 12km and the maximum number of trips these engine vans undertake is two as vans outnumber the passengers here. Therefore, the van has to wait for long periods between trips.

Since e-rickshaws can travel a distance of 70km with a one-time full charge of the battery and since the distance of the route and number of trips are 12km and 2 nos., respectively, the e-rickshaw with single full charge can easily travel the required distance without any need for charging during the day. As a result, the operating cost for e-rickshaws will automatically come down suggesting a better payback period for the e-rickshaws as compared to engine vans. The detailed fixed and operating cost calculation has been mentioned in Appendix A-4.

On the electrical infrastructure side, 18.9 MVA, 33/11kV sub-station in Sonakhali through one of its feeders (6 feeders in 33/11kV sub-station) distributes power to the Satjelia Bazar to Ashram More area which is supplied to the consumer through a number of distribution transformers (DTs) of different ratings, e.g. 25kVA, 63kVA and

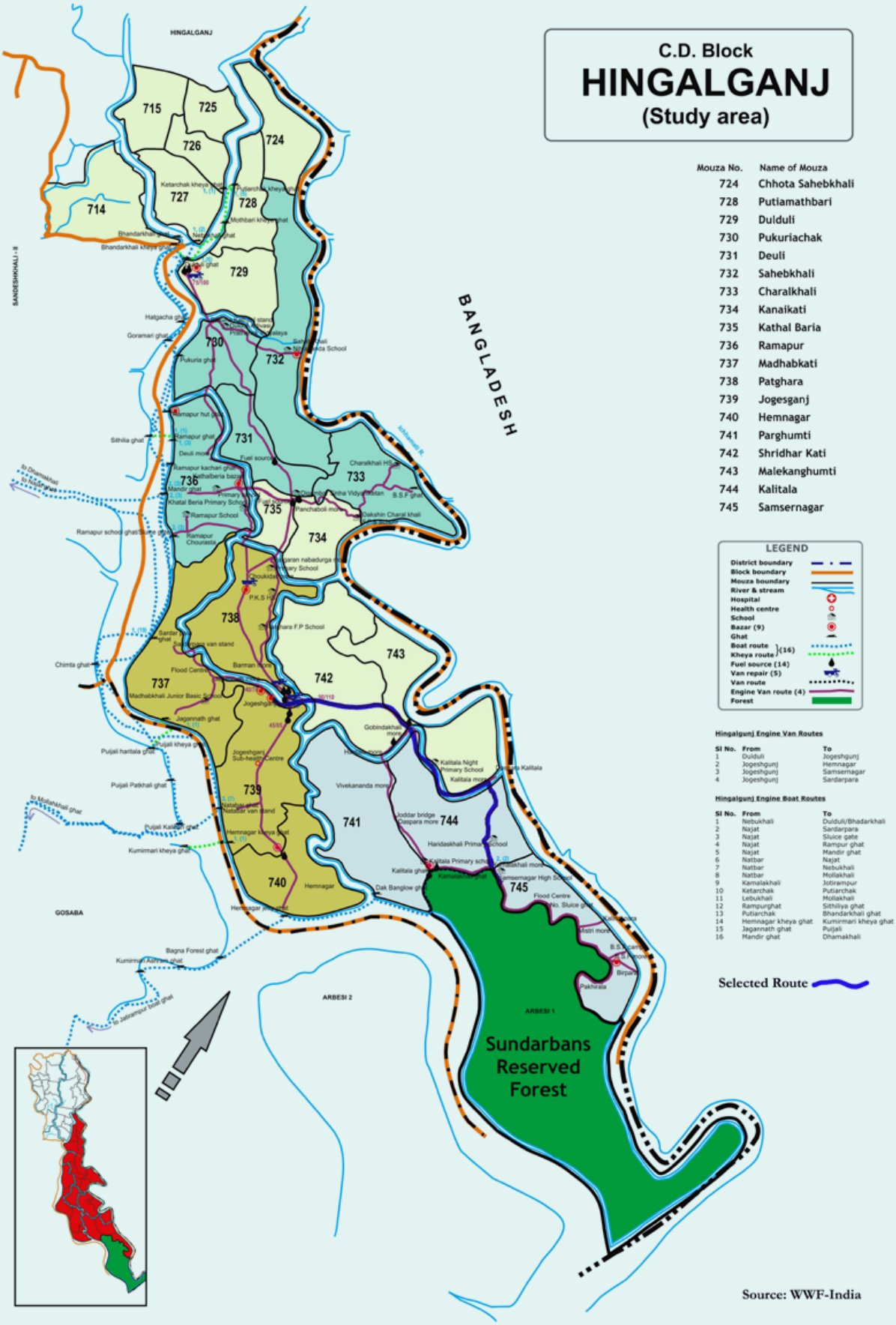
FIGURE-11: Discussion with engine van operators in Satjelia Bazar route - Ashram More, Gosaba CD Block

100kVA depending on the requirement in the area. It falls under Sonakhali sub-station and there are a total of 1066 distribution transformers with 857 nos. of 25kVA, 174 nos. of 63kVA and 35 nos. of 100kVA which supply power to all the consumers in this area.

E-rickshaws are proposed to be introduced in phases on this route, starting with batches of 20 e-Rickshaws with 5kWh batteries; to be deployed 10 each on either end of the route. The charging load of the 10 e-rickshaws at each end in a particular hour will be 50kW (10 x 5kWh). To begin with, the 63kVA and 100kVA DTs may be able to support their charging in the early morning and late night hours (full charging may be 3 hours based on the battery type and make).

DT loading in the area varies between 80% to 50% during summer and winter, respectively, which suggests availability of spare capacity in the existing DTs to cater to the additional load of the first batch of 20 e-rickshaws. Deployment of more (beyond the initial batch of 20) e-rickshaws will increase the load and the DTs might need upgradation or establishment of charging stations at both ends of this route with separate DTs. Since many of the houses and commercial buildings in the area are electrified, it will help home charging of e-rickshaws in the night. However, the power losses in the area is in the range of 80% and an increased number of DT failures (mainly during summer), makes continuous power supply a concern in the area.

FIGURE-12: Route: Jogeshganj – Samsernagar, Hingalganj CD Block



3.5 JOGESHGANJ – SAMSERNAGAR, HINGALGANJ CD BLOCK

Hingalganj is a CD Block in North 24 Parganas District of West Bengal with an area of approx. 239 sq. km. It has one Panchayat Samiti, nine Gram Panchayats, 124 village councils, and 44 inhabited villages. Jogeshganj is one of the revenue villages in Hingalganj Block and is located 27km from Hingalganj and 85km from Barasat district headquarters. The route Jogeshganj to Samsernagar connects the Jogeshganj market place to the forest fringe area of Samsernagar. Moreover, as Jogeshganj is a big market place and a hub for diesel oil purchase, this route provides the people of Samsernagar direct connectivity to the market place. The route also connects four revenue villages, namely Parghumti, Sridhar Kati, Kalitala and Samsernagar and covers various schools like Samsernagar High School, Kalitala Primary School.

The route is mainly brick paved and is wide enough to cater to two vehicles at a time except in some portions where only one vehicle can pass. However, the road is in poor condition as it is broken in some places which increases the risk of accidents and physical damage to the vehicle. The thick blue line in the given map indicates the selected route.

Based on information derived from discussions with the union secretary and drivers of engine vans, more than 100 vans are registered in this route while 50 vans operate in a single day. The distance of the route is around 12km and maximum number of trips these engine vans undertake is four. Since engine vans outnumber passengers once a van has completed a trip it has to wait a long duration before undertaking the next one. A few e-rickshaws have also been seen operating in the Jogeshganj area on different routes.

Since e-rickshaws can travel a distance of 70km with a one-time full charge of the battery and since the distance of the route and number of trips are 12km and 4 nos. respectively, the e-rickshaw with single full charge can easily travel the required distance without any need for charging during the day. As a result, the operating cost for an e-rickshaw will automatically come down, suggesting a better payback period for the e-rickshaws as compared to engine vans. The detailed fixed and operating cost calculation has been mentioned in Appendix A-5.

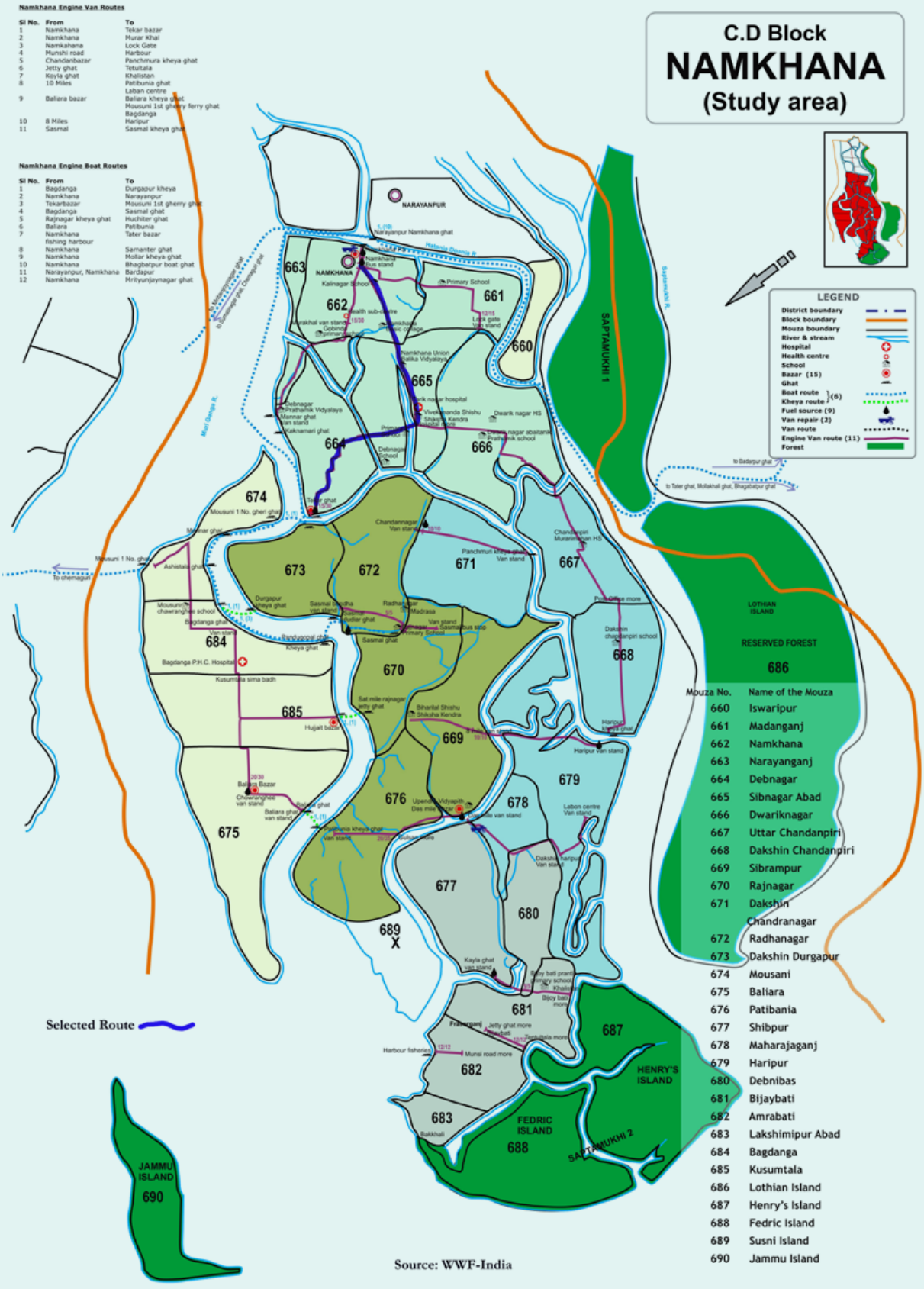
FIGURE-13:
Discussion with engine van operators in Jogeshganj – Samsernagar route, Hingalganj CD Block

On the electrical infrastructure side, 10 MVA, 33/11kV sub-station in Hingalganj through one of its feeders distributes power to the Jogeshganj to Samsernagar area, which is supplied to the consumer through a number of distribution transformers (DTs) of different ratings, for e.g. 25kVA, 63kVA and 100kVA, depending on the requirement in the area. There are more 25kVA distribution transformers than 63kVA and 100kVA distribution transformers. Distribution transformers of 16kVA are also present but are normally used to cater to the irrigation load.

E-rickshaws are proposed to be introduced in phases in this route starting with batches of 20 e-Rickshaws with 5kWh batteries. 10 can be deployed at either end of the route. The charging load of the 10 e-rickshaws at each end in a particular hour will be 50kW (10 x 5 kWh). To begin with the 63kVA and 100kVA DTs may be able to support their charging in the early morning and late-night hours (full charging may be 3 hours based on the battery type and make).

DT loading in the area varies between 60% to 40% during summer and winter, respectively, which suggests availability of spare capacity in the existing DTs to cater to the additional load of the first batch of 20 e-rickshaws. Deployment of more (beyond the initial batch of 20) e-rickshaws will increase the load and the DTs might need upgradation or establishment of charging stations at both ends of this route with separate DTs. Since most of the houses and commercial buildings in the area are electrified, it will help home charging of e-rickshaws at night. However, since the power losses in the area is more than 80% and DT failures increase during summer, continuous power supply is a concern in the area.

FIGURE-14: Route: Tekar Bazar – Namkhana, Namkhana CD Block



3.6 TEKAR BAZAR – NAMKHANA, NAMKHANA CD BLOCK

Namkhana is a CD Block in South 24 Parganas District of West Bengal with an area of approx. 371 sq. km. It is the administrative division of Kakdwip sub-division and is located 93km from Alipore district headquarters. Tekar Bazar is a part of the Debnagar mouza in Namkhana block. The route from Tekar Bazar to Namkhana connects the Tekar Bazar ghat to Namkhana Bus stand. The route connects three revenue villages, namely Namkhana, Debnagar and Sibnagar Abad and also covers colleges, schools and hospitals like Namkhana Basic College, Kalinagar School, Vivekananda Sishu Siksha Kendra, and Tarik Nagar Hospital.

The route is a mix of bituminous and brick-paved road and is wide enough to cater to two vehicles at a time except in some portions where only one vehicle can pass. However, the condition of the road is poor in some areas, since the road is broken and can cause accidents and physical damage to the vehicles. The thick blue line in the given map indicates the selected route.

Based on information derived from discussions with the union secretary and drivers of engine vans, 30 vans are currently operating in the route. The distance of the route is around 6km and maximum number of trips these engine vans can undertake is four as the engine vans outnumber passengers, forcing the former to wait long periods in between trips. A few e-rickshaws have also been operating in this route.

Since an e-rickshaw can travel a distance of 70km with a one-time full charge of the battery and since the distance of the route and number of trips are 6km and 4 nos., respectively, the e-rickshaw with single full charge can easily travel the required distance without any need for charging during the day. As a result, the operating cost for e-rickshaws will automatically come down, suggesting a better payback period for the e-rickshaws as compared to engine vans. The detailed fixed and operating cost calculation has been mentioned in Appendix A-6.

On the electrical infrastructure side, the 25.2 MVA, 33/11kV sub-station in Kakdwip, through one of its feeders, distributes power to the Tekar Bazar to Namkhana area. This is supplied to the consumer through a number of distribution transformers (DTs) of different ratings, for e.g. 25kVA, 63kVA and 100kVA, depending on the requirement

FIGURE-15: Engine vans in Tekar Bazar – Namkhana route, Namkhana CD Block

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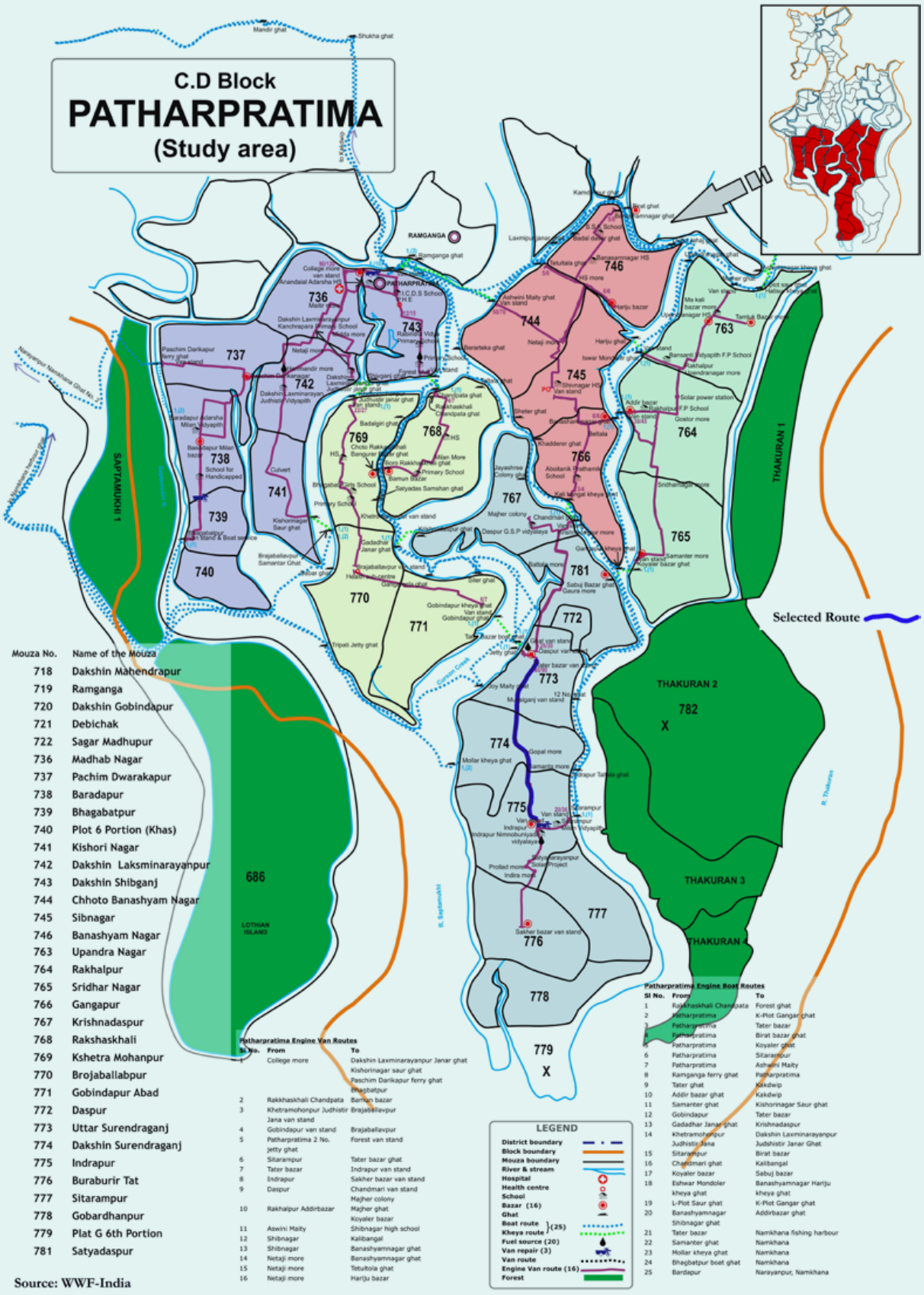
in the area. There are more 25kVA distribution transformers compared to 63kVA and 100kVA distribution transformers. Distribution transformers of 16kVA are also there but are normally used to cater to irrigation loads.

It is proposed that e-rickshaws will be introduced in phases in this route, starting with batches of 20 e-Rickshaws with 5kWh batteries, each end of the route receiving 10 e-rickshaws each. The charging load of the 10 e-rickshaws at each end in a particular hour will be 50kW (10 x 5kWh). To begin with, the 63kVA and 100kVA DTs may be able to support their charging in the early morning and late night hours (full charging may be 3 hours based on the battery type and make).

DT loading in the Tekar Bazar to Namkhana area varies between 80% to 60% during summer and winter, respectively with 80% loading at the peak time, which suggests availability of spare capacity in the existing DTs to cater to the additional load of the first batch of 20 e-rickshaws. Deployment of more (beyond the initial batch of 20) e-rickshaws will increase the load and the DTs might need upgradation or establishment of charging stations at both ends of this route with separate DTs. Since most of the houses and commercial buildings in the area are electrified, it will help in installation of charging stations. However, due to high power losses in the area, which is more than 80%, and an increased number of DT failures mainly during summer, continuous power supply is a concern in the area.

FIGURE-16: **Route: Tater Bazar – Indrapur Van Stand, Patharpratima CD Block**



3.7 TATER BAZAR – INDRAPUR VAN STAND, PATHARPRATIMA CD BLOCK

G Plot is a Panchayat in Pathar Pratima CD Block in South 24 Pargana district of West Bengal. It is located 110km from the Alipore district headquarters and 15km from Pathar Pratima. The G Plot Panchayat consists of 11 revenue villages and Tater Bazar and Indrapur Van Stand are situated in Uttar Surendraganj and Indrapur revenue villages, respectively. The route connects the Tater Bazar ferry ghat, Panchayat office and the market place in Indrapur and passes through three revenue villages, namely Uttar Surendraganj, Dakshin Surendraganj and Indrapur. This route also covers various schools like Sitarampur Milan Vidyapith, Indrapur Nimnobuniyadi Vidyalaya and fuel stations.

The route is a mix of bituminous and brick-paved road and is wide enough to cater to two vehicles at a time. However, the condition of the road is poor in some areas where the road is broken. The thick blue line in the given map indicates the selected route.

Based on the facts learnt from discussions with the union secretary and drivers of engine vans, currently, there are 70 engine vans registered in the union for this van stand, though 26 engine vans normally operate on a daily basis in the different routes in G Plot. The distance of the route is around 6.5km and the maximum number of trips these engine vans undertake is four, since vans outnumber passengers and have to wait long periods between trips.

Since e-rickshaws can travel a distance of 70km with a one-time full charge of the battery and since the distance of the route and number of trips are 6.5km and 4 nos., respectively, the e-rickshaw with single full charge can easily travel the required distance without any need for charging during the day. As a result, the operating cost for e-rickshaws will automatically come down suggesting a better payback period for the e-rickshaws as compared to engine vans. The detailed fixed and operating cost calculation has been mentioned in Appendix A-7.

On the electrical infrastructure side, a 25.2 MVA, 33/11kV sub-station in Kakdwip through one of its feeders distributes power to the Tater Bazar to Indrapur Van Stand area which is supplied to the consumers through a number of distribution transformers (DTs) of different ratings, for e.g. 25kVA, 63kVA and 100kVA, depending on the requirement in the area. There are more 25 kVA distribution transformers compared to

FIGURE-17:
Discussion with engine van operators in Tater Bazar – Indrapur Van Stand route, Patharpratima CD Block

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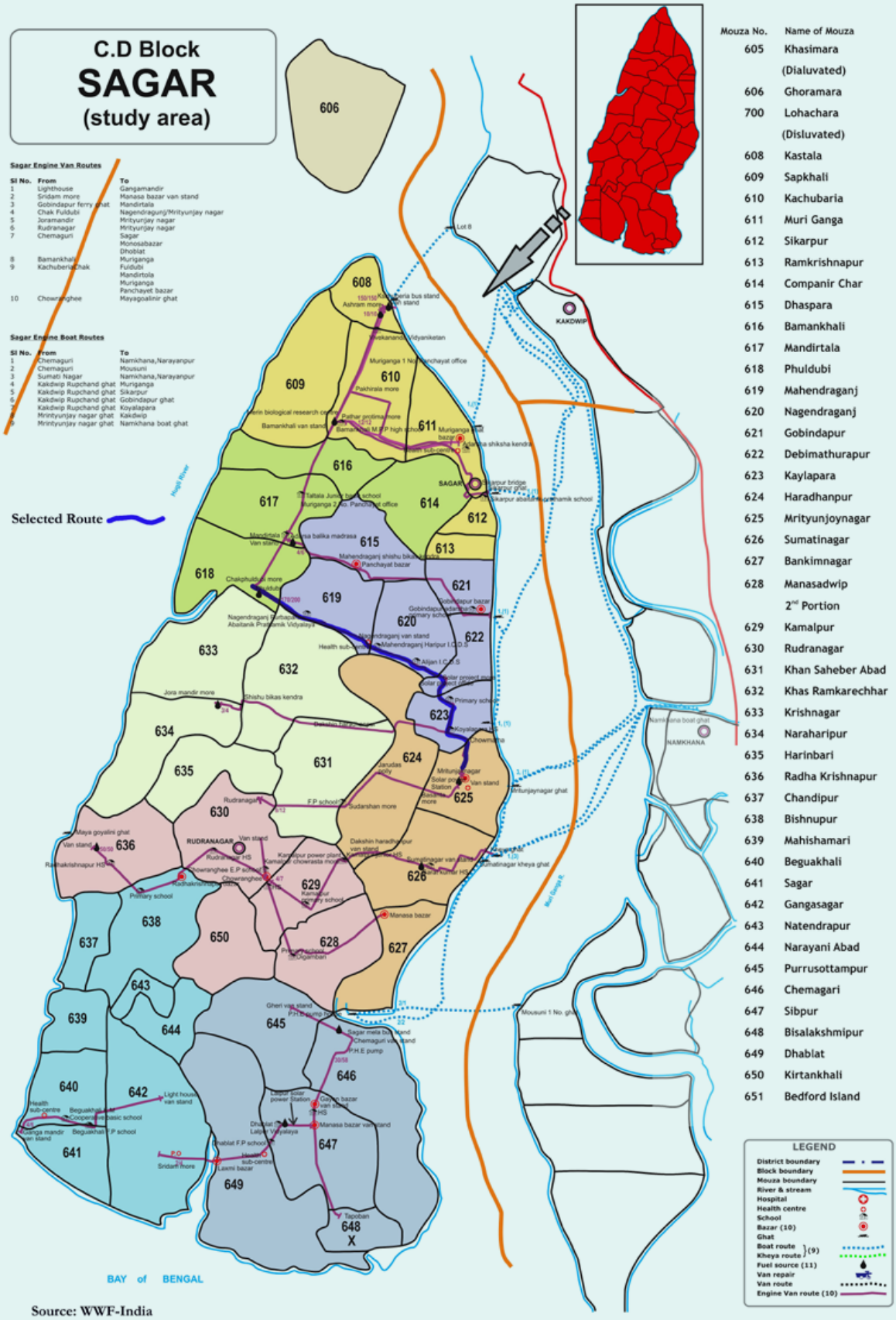
63kVA and 100kVA distribution transformers. There are distribution transformers of 16kVA as well but are normally used to cater to irrigation loads. A 110kWp solar power project installed in Indrapur by WBREDA, which is currently non-functional, can be converted into a charging station for e-rickshaws.

It is proposed that e-rickshaws will be introduced in phases in this route starting with batches of 20 e-Rickshaws with 5kWh batteries, with 10 deployed at each end. The charging load of the 10 e-rickshaws at each end in a particular hour will be 50kW (10 x 5kWh). To begin with the 63kVA and 100kVA DTs may be able to support their charging in the early morning and late-night hours (full charging may be 3 hours based on the battery type and make).

DT loading in the Tater Bazar to Indrapur Van Stand area varies between 60% to 40% during summer and winter, respectively, with 60% loading at the peak time, which suggests availability of spare capacity in the existing DTs to cater to the additional load of the first batch of 20 e-rickshaws. Deployment of more (beyond the initial batch of 20) e-rickshaws will increase the load and the DTs might need upgradation or establishment of charging stations at both ends of this route with separate DTs. Since most of the houses and commercial buildings in the area are electrified, it will help in installation of charging stations. However, due to high power losses in the area which is more than 80% and increased number of DT failures mainly during summer, continuous power supply is a concern in the area.

FIGURE-18: Route: Chak Phuldubi – Mrityunjaynagar, Sagar CD Block



Source: WWF-India

3.8 CHAK PHULDUBI – MRITYUNJAYNAGAR, SAGAR CD BLOCK

Sagar is an island in the Ganges delta located 100 kms south of Kolkata and forms an administrative division in Kakdwip sub-division of South 24 Parganas district in West Bengal. It consists of 37 revenue villages of which the Chak Phuldubi and Mrityunjay Nagar van stands are situated in Phuldubi and Mrityunjaynagar revenue villages, respectively. The route connects the market place of Chak Phuldubi to Mrityunjaynagar and passes through six revenue villages namely Phuldubi, Mahendraganj, Nagendraganj, Debimathurapur, Kaylapara and Mrityunjaynagar. This route also covers various schools and health centers like Kaylapara High School and Nagendraganj Health Sub-Center.

The route is a mix of bituminous and brick-paved road and is wide enough to cater to two vehicles at a time except in some portions where only one vehicle can pass. However, the condition of the road is not good as in some areas the road is broken and can cause accidents and physical damage to the vehicle. The thick blue line in the given map indicates the selected route.

Based on facts derived from discussions with the union secretary and drivers of engine vans, currently 15 vans are operating in the route. The distance of the route is around 10km and maximum number of trips these engine vans undertake is two as the vans outnumber the number of passengers, forcing the engine van to wait long durations between trips.

Since an e-rickshaw can travel a distance of 70km with a one-time full charge of the battery and since the distance of the route and number of trips are 10km and 2 nos. respectively, the e-rickshaw with single full charge can easily travel the required distance without any need for charging during the day. As a result, the operating cost for e-rickshaws will automatically come down suggesting a better payback period for the e-rickshaws as compared to engine vans. The detailed fixed and operating cost calculation has been mentioned in Appendix A-8.

On the electrical infrastructure side, the 25.2 MVA, 33/11kV sub-station in Kakdwip, through one of its feeders, distributes power to the Chak Phuldubi to Mrityunjaynagar area which is supplied to the consumer through a number of distribution transformers (DTs) of 25kVA. Distribution transformers of 16kVA are also present but are normally

FIGURE-19:
Discussion with engine van operators in Chak Phuldubi – Mrityunjaynagar

used to cater to the irrigation load. Moreover, a 26kWp solar power project was installed in Mrityunjaynagar by WBREDA, but is currently non-functional. This can be converted into a charging station for the e-rickshaws.

It is proposed that e-rickshaws will be introduced in phases in this route starting with batches of 20 e-Rickshaws with 5kWh batteries. 10 e-rickshaws can be deployed at each end. The charging load of the 10 e-rickshaws at each end in a particular hour will be 50kW (10 x 5 kWh). To begin with, the 63kVA and 100kVA DTs may be able to support their charging in the early morning and late night hours (full charging may be 3 hours based on the battery type and make).

Since the deployment of e-rickshaws will increase the electrical load due to charging, the DTs need to have spare capacity to accommodate the additional load or separate transformers need to be installed to cater to the envisaged increase in load. DT loading in the Chak Phuldubi to Mrityunjaynagar area varies between 80% to 60% during summer and winter, respectively with 60% loading at the peak time, which suggests availability of spare capacity in the existing DTs to cater to the additional load of the first batch of 20 e-rickshaws. Deployment of more (beyond the initial batch of 20) e-rickshaws will increase the load, so the DTs might need upgradation, or charging stations need to be established at both ends of this route with separate DTs. Since many of the houses and commercial buildings in the area are electrified, it will help in installation of battery swapping stations, charging stations or commercial meters for charging. However, due to high power losses in the area which is more than 80% and increased DT failures mainly during summer, continuous power supply is a concern in the area.

3.9 ASSESSMENT SUMMARY

The above calculations are solely based on interaction with owners and drivers of engine vans and e-rickshaws. The price of these engine vans and e-rickshaws may vary depending upon the type and user requirement, for e.g., an engine van with differential is much costlier compared to an engine van without differential. Therefore, we have considered a standard price for engine vans and the price of e-rickshaws has been considered as per the ICAT-approved model. However, there are various cases that need to be considered with reference to the cost comparison between engine vans and e-rickshaws.

The operating cost for the e-rickshaw will be reduced if lithium ion battery is used, as the cost of lithium ion battery will be double that of lead acid battery, but life of lithium ion battery will be five times the life of lead acid battery. Moreover, DC-DC roundtrip efficiency of lithium ion battery is greater than 95% as compared to 75% DC-DC roundtrip efficiency of lead acid battery.

The pay back period for e-rickshaws with lithium ion battery is slightly higher than the payback period for e-rickshaws with lead acid battery, however as the operating cost of e-rickshaws with lead acid battery is more due to lower efficiency and replacement of battery every year, therefore, Net Present Value or NPV is higher for the e-rickshaws with lithium ion battery which suggests that these e-rickshaws will fetch good return in long term.

The cost per km of e-rickshaws with lithium ion battery is lower than e-rickshaws with lead acid battery, but the cost will vary depending on the size of the lithium ion battery which will subsequently depend on the route length it has to cover.

If the engine van with differential will be used, then the total fixed cost will increase as compared to the value considered in the cost comparison and subsequently the cost per km for the engine van will also increase and profitability will reduce.

Similarly for e-rickshaw, charger cost has been incorporated in the fixed cost for the vehicle, however if the e-rickshaw owner charges the vehicle in a public charging station or swaps the battery in battery-leasing agencies then there will be no fixed cost but there will be an operational cost in the form of service fee in addition to the electricity cost for charging or for renting the charged battery. As a result, the payback period will be reduced as well as the cost per km.

In addition to that, the deployment of e-rickshaws will also contribute in reducing carbon dioxide emission which will not only be beneficial for the environment but will also help in reducing the cost associated with health problems due to air pollution, environmental damage, carbon sequestration, etc. The table 18 shows the amount of carbon dioxide emission from engine vans in a year in all the eight selected routes. For the calculation we have considered approx. 2.6444kg[6] of carbon dioxide is emitted on burning one litre of diesel.

6 https://shaktifoundation.in/wp-content/uploads/2017/06/WRI-2015-India-Specific-Road-Transport-Emission-Factors.pdf

TABLE-18: Carbon Dioxide Emissions along selected routes

Sl. No.	*Origin*	*Destination*	*Fuel Consumed per van in a year (litre)*	*Number of vans operating in this route*	*Carbon dioxide emission (kg/ year) approx.*
1	Tushkhali	Duchnikhali	720	80	1,52,317
2	Jamtala	Vasha Paanch Matha More	800	60	1,26,931
3	Sonakhali	Jhorkhali	880	50	1,16,354
4	Satjelia Bazar	Ashram More	480	60	76,159
5	Jogeshganj	Samsernagar	960	50	1,26,931
6	Tekar Bazar	Namkhana	480	30	38,079
7	Tater Bazar	Indrapur Van Stand	520	26	35,752
8	Chak Phuldubi	Mrityunjaynagar	400	15	15,866
Total carbon dioxide emission in these routes per annum					**6,88,389**

Source: India Specific Road Transport Emission Factors, India GHG Program, 2015

With the cost comparison and greenhouse gas reduction calculation in place in all the identified eight routes, it can be inferred that the deployment of e-rickshaws will not only be beneficial in terms of cost and revenue generation but will also facilitate reduction of greenhouse gases. This will help the people of the Sundarbans to have an environment friendly stream for income generation along with the option to maintain a healthy life and restore the natural heritage of the Sundarbans eco-region. To achieve this objective, an action plan to accelerate the deployment of e-rickshaws in the Sundarbans region has been charted out and is discussed in the next section.

4. ACTION PLAN

Considering both existing and envisaged policy and technology landscape for electric vehicles in India along with our assessment of the transport scenario, institutional mechanisms, financial readiness, electrical infrastructure prevailing in the Sundarbans region, a brief action plan has been presented below. With focus on surface transport, mainly the engine-based vans which are the major means of transport in island parts of the Sundarbans and beyond; the action plan has detailed the key steps that need to be taken in terms of policy and regulations, incentive mechanisms, financing availability, grid upgradation, capacity development and institutional changes required in order to carry out successful deployment of e-rickshaws and related infrastructure in the Sundarbans region.

4.1 POLICY, REGULATIONS AND INCENTIVE MECHANISMS

1. The Ministry of Transport, Govt. of West Bengal needs to develop a policy for introducing and promoting electric vehicles in all parts of West Bengal. The department should draw up guidelines defining the incentives, like subsidies on CAPEX for e-rickshaws, rebate on tariff for e-rickshaw charging, etc.
2. West Bengal Transport Department in consultation with Zilla Parishad, Panchayat Samiti and Gram Panchayat need to define Green Routes for the movement of e-rickshaws, along with developing a Master Plan and Roadmap for deployment of e-rickshaws in the Sundarbans. The road infrastructure in the selected routes for deployment of e-rickshaws must be improved to ensure safety and accident-free movement of e-rickshaws.
3. Ministry of Transport, Govt. of West Bengal in consultation with West Bengal Transport Corporation and Regional Transport Offices, need to develop regulatory guidelines for simplifying the process of e-rickshaw registration and other necessary legal compliance related issues to accelerate e-rickshaw deployment.
4. Ministry of Transport, Govt. of West Bengal should introduce the provision for inclusion of e-rickshaws under the Gatidhara scheme for extending these financial benefits to e-rickshaw owners.
5. As e-rickshaws nowadays have both lead acid and lithium ion battery, Government of West Bengal should provide more subsidy on the CAPEX for lithium ion-based e-rickshaws to promote its use, as its initial cost is much higher but lifecycle cost is much lower than lead acid batteries; and are environment friendly.
6. Regional Transport Offices need to ensure single-window clearance for issuance of license and other legal formalities for e-rickshaw registration to ensure hassle-free processing.
7. State government should ensure rebate on vehicle insurance, road tax, etc. and relaxation on vehicle permit for e-rickshaws.
8. Incentives like free parking in the tourist places should be introduced to promote more usage of e-rickshaws by the tourists.

4.2 FINANCING AVAILABILITY

1. Commercial banks, rural cooperatives, microfinance institutions can provide low cost vehicle loans for purchase of e-rickshaws under a special category, considering its positive environmental impact.
2. All the rural cooperatives in the Sundarbans region should come up with green business schemes for facilitating low cost loans for the purchase of e-rickshaws. The loan can be given for a partial amount with the condition of mortgaging the e-rickshaw in the name of the cooperative, while repayment of loans can be made on weekly or monthly basis based on the loan amount granted.
3. Self Help Groups should be encouraged by the cooperatives like Samabay Krishi Unnayan Samiti and other rural banks to avail low cost loans for purchase of e-rickshaws, and for setting up charging stations to facilitate charging of e-rickshaws or invest in other allied services.
4. For a battery leasing business model, a particular battery manufacturing company can be given the contract for a particular area with the condition that the battery manufacturer can provide funds to the Panchayat through the government as a part of their CSR activity, which can be used as a subsidy for procurement of e-rickshaws. However, the commercial viability of a battery-leasing model depends on volume maximization, i.e. a large number of e-rickshaws need to be operational.
5. PSUs may be invited to offer subsidies for e-rickshaws or to setup charging stations under their CSR initiatives.

4.3 BUSINESS MODEL

1. Appropriate locations may be selected to install charging stations – ideally nearer to the Distribution Transformers at both ends of each route. These charging stations may be owned and operated by the Rickshaw Operators Unions. The Unions may be given subsidies/grants for installation of the charging stations.
2. E-rickshaws can be charged at home in the night which may be permitted by the electric utility under special category (EV) or commercial consumer category.
3. Additional charging stations may be installed en-route at major e-rickshaw stands so that e-rickshaws can charge while they wait in queue for passengers.
4. As the type-approval certificate from GoI-authorised agencies like ICAT is mandatory, owners can buy the approved models, (i.e. only the body) and lease battery from battery leasing agencies against a specified fee. This will become commercially viable for the battery leasing agencies when the number of e-rickshaws operating in the area will be large in number.
5. Battery swapping can be considered as an option where e-rickshaws can swap their discharged battery with a charged battery in battery swapping stations whenever required.
6. Hotels and resorts can provide e-rickshaws to customers staying in the hotel for local sightseeing or to travel to the nearby jetty and can also install chargers or

battery banks for charging outside their premises to be used by other e-rickshaw drivers against a specified fee.

7. Popular tourist spots can be declared by the government as 'e-rickshaw-only' areas and can place chargers near those areas to promote e-rickshaws.
8. Gram Panchayats can also invest in charging stations or battery banks, with money from their rural development fund, to promote e-rickshaws in their areas.

4.4 GRID UPGRADATION

1. With the deployment of e-rickshaws, the electrical load will increase which may lead to overloading of the distribution network. The WBSEDCL should prepare a plan for distribution grid upgradation according to the Master Plan and Roadmap for deployment of e-rickshaws in the Sundarbans.
2. There are many solar microgrids in the Sundarbans; many of which are non-functional because of lack of maintenance and non-functional battery banks. The demand for electric vehicle charging presents an opportunity to salvage these microgrids which could also feed into the grid, though its commercial viability has to be examined. The power generation source in functional microgrids may be increased with the addition of Solar PV and the capacity of the battery banks may be enhanced to meet the additional power demand from E-Rickshaws planned for deployment in those pockets.
3. Viability of battery swapping stations or battery banks for charging with roof top solar may also be explored. Space for these installations can be provided by Gram Panchayats, e.g. two such installations are there in Satjelia Island which was deployed by WWF-India.
4. Presently, round-the-clock electricity supply in the Sundarbans being a challenge, WBSEDCL may undertake appropriate plans to improve the situation. In coordination with WBREDA, Solar PV units with Battery Banks may be established in routes selected for deployment of e-Rickshaws. WBSEDCL may avail subsidies/ grants from the Ministry of Power, GoI under various programs for improvement of electricity distribution infrastructure.

4.5 CAPACITY DEVELOPMENT AND INSTITUTIONAL CHANGES

1. Institutional mechanisms for licensing and registration of e-rickshaws including validation of the standard and certified models need to be in place and standard operating procedure for registration and licensing should be developed with RTO as the lead in implementing the procedure.
2. Standard guidelines citing the role of Zilla Parishad, Panchayat Samiti and Gram Panchayat need to be in place specifically for the Sundarbans region for disbursement of funds and subsidies related to promotion of e-rickshaws in the area. The Gram Panchayat may be given the principal responsibility of overseeing the process at the recipient end. Appropriate monitoring mechanisms should also

be developed at all three levels to ensure that the right amount has been disbursed at the right time and reaches the right hands.

3. Gram Panchayat has to play an important role by being the facilitator in the whole process from helping the e-rickshaw owners in the registration process to issuance of license, monitoring the operation of the unions to dispute resolution (if any) with RTO and therefore should be recognized as the overseeing authority for the e-rickshaw deployment process at the grassroot level.
4. Skill development and training for local people should be done in the areas of servicing of e-rickshaws and hands-on training on e-rickshaw components like motors, batteries, operation of battery banks with roof top solar panels, etc. This will help to create green job opportunities for the local residents.
5. Training centres can be opened locally for skill development of e-rickshaw drivers, technicians, etc. authorised by Automotive Skill Development Council (part of Pradhan Mantri Kaushal Vikas Yojana) which is promoted by DHI and National Skill Development Corporation along with automobile associations like ARAI, SIAM, etc.
6. Regional Transport Offices may consider implementing a single-window system enabling people to submit regulatory documents at a single location and/or single entity at CD Block level. This might help in large-scale adoption of legally approved models of e-rickshaws in remote rural and geographically challenging landscapes like the Sundarbans.
7. Gram Panchayats may be made nodal agencies for all schemes related to deployment of e-rickshaws.

In addition to points mentioned in the action plan, the process for deployment of e-rickshaws in remote, rural and geographically challenging landscapes like the Sundarbans will also require interaction with grassroot-level institutions like Gram Panchayat, Panchayat Samiti, Zilla Parishad and the union heads of various engine van stands in order to provide them with adequate knowledge on the technology, operating procedure and benefits of e-rickshaws in terms of commercial, social and environment benefits. This interaction will also allow them to communicate their viewpoint on the deployment of e-rickshaws in the Sundarbans region. This public outreach process needs to be initiated at the government level with Transport Department (West Bengal Transport Corporation) being the nodal point for the discussion.

5. WAY FORWARD

The deployment of electric vehicles on a large scale in the Sundarbans region will not only help in greenhouse gas and air pollution reduction in the Sundarbans area but will also enhance the quality of life of the people residing in the region, and restoring the area's characteristic of being an eco-region of national and global importance. There will be potential for higher income generation through the creation of more job opportunities in the electric vehicle sub-sector and related areas like in charging stations, etc. With deployment of e-rickshaws, the electricity distribution network is expected to be strengthened, which will improve the overall power supply situation in the routes selected for deployment of e-rickshaws. Reliable round-the-clock electricity supply will also bring in immense opportunities for economic and social welfare of the population living in those areas.

Socio economic development through better jobs, skill development + Increased electrification to support the EV deployment + Reduced air pollution and better human health + Alternative usage of other energy sources & more usage of green and clean energy + Increase in income through sustainable tourism

Water transport is one of the major forms of transport in the Sundarbans region. According to WWF-India, 4000 tonnes of greenhouse gases per year are being emitted by the ferries serving the island parts of the Sundarbans. Cases of oil leakage in the river by these ferries have also been witnessed, therefore these ferries are not only contributing to air pollution but are also responsible for damaging aquatic life. Majority of the ferries operating in the area are mainly medium-sized boats made of wood which are not safe to operate during rough weather conditions. Considering these factors, deployment of electric ferries is the need of the hour and will require strategic planning and development of an implementation roadmap in terms of technology selection, charging stations for boats, electrical infrastructure, business models, regulatory guidelines, etc.

Technology identification for boats, battery and motor specification, pricing + Charging Business model - floating charging station or at jetty, battery swapping for small boats, etc. + Extension of electrical network to jetty and underground cabling, network upgradation, etc. + Regulatory and operating guidelines, inclusion in financing schemes like Jaladhara, etc. + Institutional mechanism for electric boat licensing, SOP, etc. Training and skill development

To promote the deployment of electric ferries, West Bengal State Government's financing schemes like Jaladhara, where 30% of the cost of mechanised boats, up to maximum one lakh, is being provided by the state government as financial assistance, can also be extended to buyers of electric ferries as a form of subsidy. This will not only improve financial viability but will also encourage private owners to invest in electric ferries. Enabling transition to electric mobility (both surface and water transport) will enhance the sustainability factor for the transportation sector as well as the living standard of people residing in the Sundarbans region.

APPENDIX

Considering the number of trips, maximum number of passengers allowed in a single trip, fare per trip, oil consumption, Lithium Ion battery capacity and maximum passenger capacity of e-rickshaws, distance travelled per charge for e-rickshaws, fixed and operating cost comparison and payback period (including vehicle cost) between engine vans and e-rickshaw with lithium-ion battery for all the routes has been calculated and shown route-wise in the next section.

APPENDIX A-1:
TUSHKHALI – DUCHNIKHALI, SANDESHKHALI-II CD BLOCK

TABLE-19: Cost comparison between an engine van and e-rickshaw with lithium-ion battery of 4 kWh in Tushkhali – Duchnikhali route

For 1st Year			
Engine Van		***E-rickshaw***	
Parameters	***Amount***	***Parameters***	***Amount***
Cost of engine van	1,20,000	Cost of e-rickshaw	1,80,000
		Cost of charger/e-rickshaw	8,000
Vehicle maintenance cost for 1 year	9,500	Vehicle maintenance cost for 1 year	8,000
		Battery replacement cost	0
Registration and Road Tax	0	Registration and Road Tax	8,500
Insurance	0	Insurance	5,000
Other taxes	0	Other taxes	1,500
Mileage (km/ltr)	18	Mileage (km/kWh)	20
Driver's Wages per year	90,000[7]	Driver's Wages per year	90,000
Distance driven per month (km)	900	Distance driven per month (km)	1,050
Cost of diesel (INR/ltr)	75	Cost of electricity (INR/kWh)	5.26
Working days	25	Working days	25
Fuel cost/year = {900*12)/18}*75 = 45,000		***Electricity Cost/year = {(1050*12)/20} *5.26 = 3,314 (approx.)***	
Total cost: CAPEX= 1,20,000 OPEX= 9,500 + 45,000 + 90,000 = 1,44,500		***Total cost: CAPEX= 1,80,000 + 8,000 + 8,500 = 1,96,500 OPEX= 8,000 + 5,000 + 1,500 + 3,314 + 90,000 = 1,07,814***	
Fare per trip per passenger	12	Fare per trip per passenger	12
Number of passengers per trip	9	Number of passengers per trip	7
Number of trips per day	6	Number of trips per day	7
Revenue/year = 12*9*6*25*12 = 1,94,400		***Total revenue = 12*7*7*25*12 = 1,76,400***	
Net Revenue = 1,94,400 - 1,44,500 = 49,900		***Net Revenue = 1,76,400 – 1,07,814= 68,586***	
		Payback Period = CAPEX/Net Revenue = 1,96,500/68,586= 2.87 years = 2 years 10 months	
****All figures are in INR***			
Source: ISGF			

In the above calculation, we have taken one extra trip for e-rickshaws. This is because, it is a long-distance route and e-rickshaws can afford to travel some kilometres without passengers (due to low operating cost) and can take passengers in between instead of wasting time in queue at the stand. In addition, maintenance cost has also been taken on the higher side to factor in any changes which was not accounted for and because the e-rickshaw charger cost can be waived off as the owner can charge at any public charging point by providing the required fees (electricity cost and a service fee).

7 Minimum Wages at the rate of INR 300/day for 25 days a month (300*25*12=90,000)

APPENDIX A-2:
JAMTALA – VASHA PANCH MATHA MORE, KULTALI CD BLOCK

TABLE-20: Cost comparison between an engine van and e-rickshaw with lithium-ion battery of 4kWh in Jamtala – Vasha Panch Matha More route

For 1st Year			
Engine Van		***E-rickshaw***	
Parameters	***Amount***	***Parameters***	***Amount***
Cost of engine van	1,20,000	Cost of e-rickshaw	1,80,000
		Cost of charger/e-rickshaw	8,000
Vehicle maintenance cost for 1 year	9,500	Vehicle maintenance cost for 1 year	8,000
		Battery replacement cost	0
Registration and Road Tax	0	Registration and Road Tax	8,500
Insurance	0	Insurance	5,000
Other taxes	0	Other taxes	1,500
Mileage (km/ltr)	18	Mileage (km/kWh)	20
Driver's Wages per year	90,000[8]	Driver's Wages per year	90,000
Distance driven per month (km)	1500	Distance driven per month (km)	2250
Cost of diesel (INR/ltr)	75	Cost of electricity (INR/kWh)	5.26
Working days	25	Working days	25
Fuel cost/year = {(1500*12)/18}*75= 75,000		***Electricity Cost/year = {(2250*12)/20} *5.26= 7,101 (approx.)***	
Total cost: CAPEX= 1,20,000 OPEX/year= 9,500 + 75,000 + 90,000 = 1,74,500		***Total cost: CAPEX= 1,80,000 + 8,000 + 8,500 = 1,96,500 OPEX = 8,000 + 5,000 + 1,500 + 7,101 + 90,000 = 1,11,601***	
Fare per trip per passenger	30	Fare	30
Number of passengers per trip	10	Number of passengers per trip	7
Number of trips per day	2	Number of trips per day	3
Revenue per year = 30*10*2*25*12 = 1,80,000		***Revenue/year = 30*7*3*25*12 = 1,89,000***	
Net Revenue = 1,80,000 - 1,74,500 = 6,500		***Net Revenue = 1,89,000 - 1,11,601 = 77,399***	
		Payback Period = CAPEX/ Net Revenue= 1,96,500/77,399 = 2.54 years = 2 years 6 months	
****All figures are in INR***			
Source: ISGF			

In this calculation we have taken one extra trip for e-rickshaws. This is because, it is a long-distance route and e-rickshaws can afford to travel some kilometres without passengers (due to low operating cost) and can take passengers in between instead of wasting time in queue at the stand.

8 Minimum Wages at the rate of INR 300/day for 25 days a month (300*25*12=90,000)

APPENDIX A-3:
SONAKHALI – JHORKHALI, BASANTI CD BLOCK

TABLE-21: Cost comparison between an engine van and e-rickshaw with lithium-ion battery of 4kWh in Sonakhali – Jhorkhali route

For 1st Year			
Engine Van		***E-rickshaw***	
Parameters	***Amount***	***Parameters***	***Amount***
Cost of engine van	1,20,000	Cost of e-rickshaw	1,80,000
		Cost of charger/e-rickshaw	8,000
Vehicle maintenance cost for 1 year	9,500	Vehicle maintenance cost for 1 year	8,000
		Battery replacement cost	0
Registration and Road Tax	0	Registration and Road Tax	8,500
Insurance	0	Insurance	5,000
Other taxes	0	Other taxes	1,500
Mileage (km/ltr)	18	Mileage (km/kWh)	20
Driver's Wages per year	90,000[9]	Driver's Wages per year	90,000
Distance driven per month (km)	1320	Distance driven per month (km)	1,980
Cost of diesel (INR/ltr)	75	Cost of electricity (INR/kWh)	5.26
Working days	25	Working days	25
Fuel cost/year = {(1,320*12)/18}*75= 66,000		***Electricity Cost/year = {(1,980*12)/20} *5.26*1 = 6,249 (approx.)***	
Total cost: ***CAPEX= 1,20,000*** ***OPEX/year= 9,500 + 66,000 + 90,000 = 1,65,500***		***Total cost:*** ***CAPEX= 1,80,000 + 8,000 + 8,500 = 1,96,500*** ***OPEX= 8,000 + 5,000 + 1,500 + 6,249 + 90,000 = 1,10,749***	
Fare per trip per passenger	19	Fare per trip per passenger	19
Number of passengers per trip	6	Number of passengers per trip	6
Number of trips per day	2	Number of trips per day	3
Revenue/year = 19*6*2*25*12 = 68,400		***Revenue/year = 19*6*3*25*12 = 1,02,600***	
Net Revenue= 68,400 – 1,65,500 = -97,100		***Net Revenue = 1,02,600 - 1,10,749 = -8,149***	
		Not viable without subsidy as OPEX is more than revenue	
****All figures are in INR***			
Source: ISGF			

In the above calculation one extra trip for the e-rickshaw has been considered whereas for engine van it is two. This is because, it is a long-distance route and e-rickshaws can afford to travel some kilometres without passengers (due to low operating cost) and can take passengers in between instead of wasting time in queue at the stand.

9 Minimum Wages at the rate of INR 300/day for 25 days a month (300*25*12=90,000)

APPENDIX A-4:
SATJELIA BAZAR - ASHRAM MORE, GOSABA CD BLOCK

TABLE-22: Cost comparison between an engine van and e-rickshaw with Lithium Ion battery of 4kWh in Satjelia Bazar - Ashram More route

For 1st Year			
Engine Van		***E-rickshaw***	
Parameters	***Amount***	***Parameters***	***Amount***
Cost of engine van	1,20,000	Cost of e-rickshaw	1,80,000
		Cost of charger/e-rickshaw	8,000
Vehicle maintenance cost for 1 year	9,500	Vehicle maintenance cost for 1 year	8,000
		Battery replacement cost	0
Registration and Road Tax	0	Registration and Road Tax	8,500
Insurance	0	Insurance	5,000
Other taxes	0	Other taxes	1,500
Mileage (km/ltr)	18	Mileage (km/kWh)	20
Driver's Wages per year	90,000[10]	Driver's Wages per year	90,000
Distance driven per month (km)	600	Distance driven per month (km)	900
Cost of diesel (INR/ltr)	75	Cost of electricity (INR/kWh)	5.26
Working days	25	Working days	25
Fuel cost/year = {(600*12)/18}*75 = 30,000		***Electricity Cost/year = {(900*12)/20} *5.26 = 2,840 (approx.)***	
Total cost: ***CAPEX = 1,20,000*** ***OPEX= 9,500 + 30,000 + 90,000 = 1,29,500***		***Total cost:*** ***CAPEX= 1,80,000 + 8,000 + 8,500 = 1,96,500*** ***OPEX = 8,000 + 5,000 + 1,500 + 2,840 + 90,000 = 1,07,340***	
Fare per trip per passenger	30	Fare per trip per passenger	30
Number of passengers per trip	5	Number of passengers per trip	5
Number of trips per day	2	Number of trips per day	3
Revenue/year = 30*5*2*25*12 = 90,000		***Total revenue = 30*5*3*25*12 = 1,35,000***	
Net Revenue = 90,000 – 1,29,000 = -39,000		***Net Revenue = 1,35,000 – 1,07,340 = 27,660***	
		Payback Period = CAPEX/ Net Revenue= 1,96,500/27,660 = 7.10 years = 7 years 1 month	
****All figures are in INR***			
Source: ISGF			

In the above calculation one extra trip for e-rickshaw has been considered whereas for engine van it is two. This is because, it is a long-distance route and e-rickshaws can afford to travel some kilometres without passengers (due to low operating cost) and can take passengers in between instead of wasting time in queue at the stand.

10 Minimum Wages at the rate of INR 300/day for 25 days a month (300*25*12=90,000)

APPENDIX A-5:
JOGESHGANJ – SAMSERNAGAR, HINGALGANJ CD BLOCK

TABLE-23: Cost comparison between an engine van and e-rickshaw with lithium-ion battery of 4kWh in Jogeshganj – Samsernagar route

For 1st Year			
Engine Van		***E-rickshaw***	
Parameters	***Amount***	***Parameters***	***Amount***
Cost of engine van	1,20,000	Cost of e-rickshaw	1,80,000
		Cost of charger/e-rickshaw	8,000
Vehicle maintenance cost for 1 year	9,500	Vehicle maintenance cost for 1 year	8,000
		Battery replacement cost	0
Registration and Road Tax	0	Registration and Road Tax	8,500
Insurance	0	Insurance	5,000
Other taxes	0	Other taxes	1,500
Mileage (km/ltr)	18	Mileage (km/kWh)	20
Driver's Wages per year	90,000[11]	Driver's Wages per year	90,000
Distance driven per month (km)	1200	Distance driven per month (km)	1,500
Cost of diesel (INR/ltr)	75	Cost of electricity (INR/kWh)	5.26
Working days	25	Working days	25
Fuel cost/year = {(1200*12)/18}*75= 60,000		Electricity Cost/year = {(1,500*12)/20} *5.26*1 = 4,734 (approx.)	
Total cost: ***CAPEX= 1,20,000*** ***OPEX/year= 9,500 + 60,000 + 90,000 = 1,59,500***		***Total cost:*** ***CAPEX= 1,80,000 + 8,000 + 8,500 = 1,96,500*** ***OPEX = 8,000 + 5,000 + 1,500 + 4,734 + 90,000 = 1,09,234***	
Fare per trip per passenger	17	Fare per trip per passenger	17
Number of passengers per trip	10	Number of passengers per trip	7
Number of trips per day	4	Number of trips per day	5
Revenue per year = 17*10*4*25*12 = 2,04,000		***Revenue per year = 17*7*5*25*12 = 1,78,500***	
Net Revenue = 2,04,000 – 1,59,500 = 44,500		***Net Revenue = 1,78,500 - 1,09,234 = 69,266***	
		Payback Period = CAPEX/ Net Revenue= 1,96,500/69,266 = 2.83 years = 2 years 10 months	
****All figures are in INR***			
Source: ISGF			

In the above calculation one extra trip for the e-rickshaw has been considered, whereas for the engine van it is two. This is because, it is a long-distance route and e-rickshaws can afford to travel some kilometres without passengers (due to low operating cost) and can take passengers in between instead of wasting time in queue at the stand.

11 Minimum Wages at the rate of INR 300/day for 25 days a month (300*25*12=90,000)

APPENDIX A-6:
TEKAR BAZAR – NAMKHANA, NAMKHANA CD BLOCK

TABLE-24: Cost comparison between an engine van and e-rickshaw with lithium-ion battery of 4kWh in Tekar Bazar – Namkhana route

For 1st Year			
Engine Van		***E-rickshaw***	
Parameters	***Amount***	***Parameters***	***Amount***
Cost of engine van	1,20,000	Cost of e-rickshaw	1,80,000
		Cost of charger/e-rickshaw	8,000
Vehicle maintenance cost for 1 year	9,500	Vehicle maintenance cost for 1 year	8,000
		Battery replacement cost	0
Registration and Road Tax	0	Registration and Road Tax	8,500
Insurance	0	Insurance	5,000
Other taxes	0	Other taxes	1,500
Mileage (km/ltr)	18	Mileage (km/kWh)	20
Driver's Wages per year	90,000[12]	Driver's Wages per year	90,000
Distance driven per month (km)	720	Distance driven per month (km)	900
Cost of diesel (INR/ltr)	75	Cost of electricity (INR/kWh)	5.26
Working days	25	Working days	25
Fuel cost/year = {(720*12)/18}*75*1 = 36,000		***Electricity Cost/year = {(900*12)/20} *5.26*1 = 2,841 (approx.)***	
Total cost:		***Total cost:***	
CAPEX= 1,20,000		***CAPEX= 1,80,000 + 8,000 + 8,500 = 1,96,500***	
OPEX/year= 9,500 + 36,000 + 90,000 = 1,35,500		***OPEX = 8,000 + 5,000 + 1,500 + 2,841 + 90,000 = 1,07,341***	
Fare per trip per passenger	20	Fare per trip per passenger	20
Number of passengers per trip	12	Number of passengers per trip	7
Number of trips per day	4	Number of trips per day	5
Revenue/year = 20*12*4*25*12 = 2,88,000		***Revenue/year = 20*7*5*25*12 = 2,10,000***	
Net Revenue = 2,88,000 – 1,35,500 = 1,52,500		***Net Revenue = 2,10,000 – 1,07,341 = 1,02,659***	
		Payback Period = CAPEX/ Net Revenue= 1,96,500/1,02,659 = 1.91 years = 1 year 11 months	
****All figures are in INR***			
Source: ISGF			

In the above calculation one extra trip for e-rickshaw has been considered whereas for engine van it is two. This is because, it is a long-distance route and e-rickshaws can afford to travel some kilometres without passengers (due to low operating cost) and can take passengers in between instead of wasting time in queue at the stand.

12 Minimum Wages at the rate of INR 300/day for 25 days a month (300*25*12=90,000)

APPENDIX A-7:
TATER BAZAR – INDRAPUR VAN STAND, PATHARPRATIMA CD BLOCK

TABLE-25: Cost comparison between an engine van and e-rickshaw with lithium-ion battery of 4kWh in Tater Bazar – Indrapur Van Stand route

For 1st Year			
Engine Van		***E-rickshaw***	
Parameters	***Amount***	***Parameters***	***Amount***
Cost of engine van	1,20,000	Cost of e-rickshaw	1,80,000
		Cost of charger/e-rickshaw	8,000
Vehicle maintenance cost for 1 year	9,500	Vehicle maintenance cost for 1 year	8,000
		Battery replacement cost	0
Registration and Road Tax	0	Registration and Road Tax	8,500
Insurance	0	Insurance	5,000
Other taxes	0	Other taxes	1,500
Mileage (km/ltr)	18	Mileage (km/kWh)	20
Driver's Wages per year	90,000[13]	Driver's Wages per year	90,000
Distance driven per month (km)	650	Distance driven per month (km)	812.5
Cost of diesel (INR/ltr)	75	Cost of electricity (INR/kWh)	5.26
Working days	25	Working days	25
Fuel cost/year = {(650*12)/18}*75= 32,500		Electricity Cost/year = {(812.5*12)/20} *5.26 = 2,564 (approx.)	
Total cost:		***Total cost:***	
CAPEX= 1,20,000		***CAPEX= 1,80,000 + 8,000 + 8,500 = 1,96,500***	
OPEX/year= 9,500 + 32,500 + 90,000 = 1,32,000		***OPEX = 8,000 + 5,000 + 1,500 + 2,564 + 90,000 = 1,07,064***	
Fare per trip per passenger	15	Fare per trip per passenger	15
Number of passengers per trip	8	Number of passengers per trip	7
Number of trips per day	4	Number of trips per day	5
Revenue per year = 15*8*4*25*12 = 1,44,000		***Revenue per year = 15*7*5*25*12 = 1,57,500***	
Net Revenue = 1,44,000 - 1,32,000 = 12,000		***Net Revenue = 1,57,500 – 1,07,064 = 50,436***	
		Payback Period = CAPEX/ Net Revenue= 1,96,500/50,436 = 3.89 years = 3 years 11 months	
****All figures are in INR***			
Source: ISGF			

In the above calculation one extra trip for e-rickshaw has been considered whereas for engine van it is two. This is because, it is a long-distance route and e-rickshaws can afford to travel some kilometres without passengers (due to low operating cost) and can take passengers in between instead of wasting time in queue at the stand.

13 Minimum Wages at the rate of INR 300/day for 25 days a month (300*25*12=90,000)

APPENDIX A-8:
CHAK PHULDUBI – MRITYUNJAYNAGAR, SAGAR CD BLOCK

TABLE-26: Cost comparison between an engine van and e-rickshaw with lithium-ion battery of 4kWh in Chak Phuldubi – Mrityunjaynagar route

For 1st Year			
Engine Van		***E-rickshaw***	
Parameters	***Amount***	***Parameters***	***Amount***
Cost of engine van	1,20,000	Cost of e-rickshaw	1,80,000
		Cost of charger/e-rickshaw	8,000
Vehicle maintenance cost for 1 year	9,500	Vehicle maintenance cost for 1 year	8,000
		Battery replacement cost	0
Registration and Road Tax	0	Registration and Road Tax	8,500
Insurance	0	Insurance	5,000
Other taxes	0	Other taxes	1,500
Mileage (km/ltr)	18	Mileage (km/kWh)	20
Driver's Wages per year	90,000[14]	Driver's Wages per year	90,000
Distance driven per month (km)	500	Distance driven per month (km)	750
Cost of diesel (INR/ltr)	75	Cost of electricity (INR/kWh)	5.26
Working days	25	Working days	25
Fuel cost/year = {(500*12)/18}*75= 25,000		***Electricity Cost/year = {(750*12)/20} *5.26 = 2,367 (approx.)***	
Total cost:		***Total cost:***	
CAPEX= 1,20,000		***CAPEX= 1,80,000 + 8,000 + 8,500 = 1,96,500***	
OPEX/year= 9,500 + 25,000 + 90,000 = 1,24,500		***OPEX = 8,000 + 5,000 + 1,500 + 2,367 + 90,000 = 1,06,867***	
Fare per trip per passenger	35	Fare per trip per passenger	35
Number of passengers per trip	8	Number of passengers per trip	7
Number of trips per day	2	Number of trips per day	3
Revenue per year = 35*8*2*25*12 = 1,68,000		***Revenue per year = 35*7*3*25*12 = 2,20,500***	
Net Revenue = 1,68,000 - 1,24,500 = 43,500		***Net Revenue = 2,20,500 – 1,06,867 = 1,13,633***	
		Payback Period = CAPEX/ Net Revenue= 1,96,500/1,13,633 = 1.73 years = 1 year 9 months	
****All figures are in INR***			
Source: ISGF			

In the above calculation one extra trip for the e-rickshaw has been considered whereas for the engine van it is two. This is because, it is a long-distance route and e-rickshaws can afford to travel some kilometres without passengers (due to low operating cost) and can take passengers in between instead of wasting time in queue at the stand.

14 Minimum Wages at the rate of INR 300/day for 25 days a month (300*25*12=90,000)

The above calculation for all the eight routes shows that in cases like Sonakhali to Jhorkhali where both number of trips and passengers allowed are fewer, fare should be high to compensate for fewer number of trips and passengers per trip, otherwise without any subsidy on loan or on cost of the vehicle, e-rickshaw deployment in those routes will not be financially viable.

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The Climate Change and Energy Programme of WWF-India is working towards climate resilient future for people, places and species that support pathways for sustainable and equitable economic growth. WWF-India is actively engaged in promoting renewable energy uptake, enabling clean energy access, demonstrating renewable energy projects in critical landscapes, and overall promoting sustainable clean energy solutions. Climate innovations, low carbon development and renewable energy at scale are the thrust areas of the programme.

To know more, log on to: www.wwfindia.org

ABOUT INDIA SMART GRID FORUM

India Smart Grid Forum (ISGF) is a non-profit organization and a Public Private Partnership initiative of Ministry of Power (MoP), Government of India and closely works with central ministries of Renewable Energy, Urban Development, heavy industries, state governments, electric utilities, central & state regulatory commissions and various donor agencies. It is responsible for accelerated development of smart grid technologies and has a mandate to advise government on policies and programs for promotion of Smart Grids in India, work with national and international agencies in standards development and to help utilities, regulators and different industries in technology selection, training and capacity building.

Since inception, ISGF has been actively involved in various research activities on electric vehicles, smart grid and smart city domain and provided advisory services including capacity building and training programs to different ministries, utilities and regulatory bodies. ISGF has also published various white papers and technical reports on EV roll out strategy, vehicle to grid integration, policy requirement for electric vehicle, etc.

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